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OF THE
ROYAL BOTANIC GARDENS, PERADENIYA.

EDITED BY

T. PETCH, B.A., B.Sc.

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CONTENTS.

	PAGE
PETCH, T.—Notes on Aristolochia	1
RAGUNATHAN, C.—The Occurrence of Teleutospores in Hemileia vastatrix B. & Br.	109
PETCH, T.—Xylariaceæ Zeylanicæ	119
PETCH, T.—A Note on Diplodiella	167

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Notes on Aristolochia.

BY

T. PETCH, B.A., B.Sc.

THE observations recorded in this paper were made at intervals during the last seven years, chiefly on species of *Aristolochia* which grew in my garden at Peradeniya, with the addition of a few on the same or other species in the Royal Botanic Gardens there. They were begun on *Aristolochia ridicula,* of which an old-established plant happened to grow behind the bungalow, the other species being taken up later for comparison; hence the observations on the former species have been more extended than on the others. With the exception of *Aristolochia indica* and *A. bracteata,* the species dealt with have been introduced into Ceylon.

As is generally known, the flowers of *Aristolochia* attract insects, which enter them and remain imprisoned until some change in the flower permits them to escape. The behaviour of the European species, *Aristolochia Clematitis* L., was investigated by Sprengel and later by Hildebrand, and their researches occupy a high place in the classics of insect pollination. But very little examination appears to have been made of the numerous tropical or sub-tropical species, though their flowers, many of them of the most fantastic shape, are an unfailing source of interest, whether in tropical Botanic Gardens, or in green-houses in temperate countries, or even as depicted in botanical literature. Moreover, investigations in the tropics have led to directly contradictory theories. Ule, from observations in Brazil, agreed with Hildebrand that the flower was protogynous, and that its elaborate structure was a device to ensure cross-fertilization. Burck, from observations in Java, held that the stamens and stigma were mature at the same time, and that the whole arrangement was adapted to ensure self-fertilization.

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The objects of the observations now recorded were to obtain more exact data on the behaviour of the flowers in the tropics, and to decide if possible between the conflicting views of previous observers. It will be seen in the sequel that, although the flowers differ so much in form and structure, their behaviour is remarkably similar throughout, while, although they are without doubt adapted for cross-fertilization, some species can be self-fertilized.

It was also hoped to determine what species of insects visited the different flowers, and to estimate the effectiveness of the flowers by the relative number of insects of different species which they attracted. It has not, however, been possible to carry that out except in a general way, for the reason that very little is known about tropical Diptera and consequently the species cannot be identified.

My thanks are due to Mr. N. K. Jardine for effecting the preliminary sortation of the insects found in the flowers in the earlier stages of this investigation, and for obtaining identifications of some of these from the Imperial Bureau of Entomology. I am greatly indebted to Mr. R. Senior White for his valuable assistance in undertaking the identification of the species found subsequently.

Aristolochia ridicula N. E. Br.

The perianth consists of three parts,—the bulb, the tube, and the limb or face, all of which are thin-walled (Plate I., fig. 2).

The bulb is ovate, about 3·5 cm. long and 2·5 cm. diameter, its greatest diameter being below the middle. Its apex is produced into a short socket, into which the apex of the ovary fits. Round this socket is a clear translucent area—the window area—about 1 cm. in diameter, with a crenate edge, traversed radially by about sixteen veins which run longitudinally down the bulb from the apex. These main veins and the smaller cross veins are purple-brown, so that the bulb is mottled purple-brown on a pale green ground, the purple coloration being almost continuous on the anterior side.*

The tube leaves the bulb on the lower third of the anterior side, the wall of the bulb being invaginated round the end of the tube, more strongly above than below. The tube is vertically oval in section and about 1·5 cm. across its longest diameter, expanding slightly towards the mouth. Its total length is about 5 cm. The veins of the bulb are continued longitudinally along the tube, where they become prominent, but they are reduced to about six in the outer half. Near the outer end, however, these six fork dichotomously, the lowest twice and the others once, and thus furnish additional support for the face. The coloration of the tube resembles that of the bulb, but the purple-brown predominates and the colour is generally more intense; hence the tube is purple-brown with darker reticulations, and slightly mottled with green. The relative amounts of green and purple-brown, however, differ on different flowers, both as regards the bulb and the tube.

The limb, or face (Plate I., fig. 3), differs from that of most of the other species of *Aristolochia* cultivated in Ceylon in that it is sharply differentiated from the tube, and stands out more or less at right angles to the latter, or is bent back at an acute angle. In shape, it is triangular, with rounded corners, and with a shallow triangular sinus along the outer (lower) edge. It is about 6 cm. from point to point and 2·5 cm. broad. The mouth of the tube is oval, about 2 × 1 cm., and occupies the middle of the face. The two halves, or wings, just meet at the lower edge of the mouth, but form a border about 5 mm. wide round the upper edge. The outer ends of the wings are broadly rounded, but during the first day the flower is open their edges are strongly recurved so that the ends appear pointed. The upper margin of the face is also recurved, and the whole is slightly depressed below the level of the mouth of the tube. The outer two-thirds of each wing bears erect glands, 3 mm. high, with a translucent stalk and an opaque, purple-brown, globular tip, each arising from a small, stellate, purple-brown patch. The ground colour of the wing is yellow-green, but on the inner third it is densely covered with close-set, purple-brown lines, more or less herring-bone pattern. Each wing is supported by six strong veins, prominent on the green under-surface, the longest forking once or twice.

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* The terms anterior and posterior are used throughout to indicate position in the expanded flower.

The stalk and the whole exterior of the flower are covered with scattered, rigid hairs up to 5 mm. long. These are septate, but not hinged.

The tube is white internally, and is lined with white, rigid hairs up to 4 mm. long (Plate I., fig. 4). These hairs are of the usual hinged, or trap, type. They stand perpendicular to the wall of the tube and are slightly curved downwards in their upper half. They do not completely close the tube, but leave a free central passage of varying width. The longest hairs are situated in a ring at the edge of the mouth, and the clear central oval space is here about 2 mm. wide. Immediately below this, the free space is enlarged to a breadth of 5 mm. from which it gradually diminishes downwards, owing to the diminution of the diameter of the tube, becoming about 2 mm. broad, half-way down the tube, and 1–1·5 mm. broad at the inner end. Therefore, the flies which force their way through the ring of hairs at the mouth find a much wider free space inside, and, without taking into account the potential displacement of the hairs, it is easier for them to move down the tube than to attempt to return, at least until the middle of the tube is reached.

The hinged hairs (Plate I., fig. 6) are septate at close intervals. They are about 0·5 mm. broad at the base, diminishing to half that breadth at a height of 0·25 mm., and thence tapering to the tip. The base is almost semi-oval in plan, and is convex and somewhat oblique. The actual base is free, the hair being attached by a minute papilla (hinge) which arises at, or just above, the margin in the middle of the curved side. The hair is situated on the wall of the tube with the long axis of the base perpendicular to the length of the tube, and the more curved side inwards. The point of attachment is consequently on the inner side of the base, and while the hair can bend inwards or to either side, it breaks off if pressed strongly outwards, owing to the fracture of the hinge.

Internally, the upper part of the bulb is occupied by the window area, which is bordered by a narrow purple line (Plate I., fig. 8). The window area, though translucent, is thicker than the remainder of the wall of the bulb, as appears to be the general rule in *Aristolochia* : it bears septate hairs which are not hinged. The remainder of the wall is yellowish-white, with numerous small, purple-brown spots, and is covered with lax, woolly, somewhat viscid hairs. These hairs are septate, equal, about 25 μ diameter, and are agglutinated into fascicles.

Round the inner opening of the tube, the invaginated area of the wall forms a smooth, white region, irregularly nodular, up to 5 mm. broad above, thinning out along either side and continued as a narrow ring below (Plate I., fig. 5). The wall is here thickened, up to 1 mm. thick. Examined microscopically, this region is found to bear minute, scattered, subconical papillæ. Above this thickened area is a narrow crescentic zone, purple-gray or brownish, covered with matted hairs and appearing moist and viscid. This crescentic zone is composed of two symmetrically-placed areas, separated by a narrow median line. The thickened region, stoutest above, probably assists in keeping the flower rigid and prevents displacement of the tube.

The gynostegium, when the flower opens, is an inverted hollow cone, on a short stout stalk (Plate I., fig. 7). It is deeply divided into six triangular lobes, and the upper margin along its whole length is curved outwards, forming a fillet which projects over the anthers, but does not cover or conceal them. The edge of this fillet is bordered with minute hairs.

In the unopened flower (Plate I., fig. 1), the two wings are closely opposed, and united along their edges, forming a flattened trapezoidal apex. If the unopened flower be pressed, it bursts along the suture, but, as perforated flowers open normally, it is evident that the process of expansion is not dependent on the pressure of the contained air. The flower dehisces even when the apex is bandaged so that the wings cannot separate.

The flowers open at daybreak. On May 12, they began to open at or shortly before 5.45 A.M., and had all opened by 6.20 A.M. The separation of the wings begins on the outer vertical edge, and advances gradually upwards and along the upper edge for about half its length. It is then arrested for a few minutes (up to ten). The rupture of the remainder then occurs suddenly, with a ripping noise, and the wings spring apart. In some cases, after the initial opening of the anterior edge, the posterior shorter edge opens, leaving the wings attached along about one-half the upper edge. But the final separation is always sudden and audible. The wings bend slowly outwards and downwards to a horizontal position and remain for a short time unchanged. The upper edge of the face then begins to recurve, and this process progresses outwards along the wings, the broader part, near the mouth, curving first. When this is complete, the wings point obliquely backwards. In this last stage of expansion, the two wings act independently. The mouth is at first narrow, with parallel sides, or narrow hour-glass shaped ; it assumes its oval form during, or after, the curving of the wings. The full expansion of the flower occupies about half an hour. As a rule, only one flower on a given branch is open at one time, and successive flowers on the same branch do not open on consecutive days.

Flies are attracted to the flowers before they have fully expanded. The plant has a rank smell, which appears to emanate from a swollen zone at the base of the flower stalk, but the flower has no perceptible odour. But that the flies are attracted by some odour from the flower is evident from the following observation. A narrow tape was tied round the apex of an unopened flower, so that the wings could not spread out, and the flower was enclosed in a close-fitting bag. When the flower opened, it merely gaped, for a breadth of about one-eighth of an inch, where the edges of the apex were not kept in contact by the tape. Flies were observed to settle on the bag, and to remain for some time on the area immediately over the open part of the flower.

The attracting odour appears to emanate from the glandula processes on the wings. At 6.30 A.M., the whole of the face was cut away from eight flowers, leaving only a very narrow rim round the mouth. Twelve uninjured flowers were left. All were gathered at 4.15 P.M. Of the eight mutilated flowers, only one contained an insect, and that was an Ichneumonid. The twelve uninjured flowers contained 5, 3, 6, 4, 0, 3, 5, 1, 4, 3, 3, 2 flies respectively, or an average of 3·25 per flower. This experiment was repeated on another occasion, at 6.15 A.M. Nine flowers were mutilated, and three left uninjured. When collected at 5.30 P.M., six of the mutilated flowers did not contain any insect, one contained an ant, another a Psocid, and another a single fly of one of the kinds usually found in the flowers. The three uninjured flowers contained 9, 4, and 6 flies respectively. Thus the seventeen flowers from which the face had been removed contained between them only one fly, and there is a possibility that that one entered before the flower was treated. On the other hand, the fifteen uninjured flowers contained between them fifty-eight flies. As the tube was not injured in any way, the possibility that the flies had escaped from the mutilated flowers is excluded.

Ants are frequently found in the flowers. Evidently the hairs on the stalk and perianth do not prevent their passage along the exterior of the flower.

As is well known, insects which enter the flower do so by pushing the hairs downwards or to one side. But as the hairs cannot be bent back towards the entrance, they are compelled to remain in the bulb until the hairs have withered. That rule, however, is not universal. On several occasions, when examining flowers in the morning, about 8 A.M., I have heard a loud buzzing, and on seeking the cause have found one of the largest flies which visit the flowers (*Sarcophaga* sp.), half-way down the tube of a recently-opened flower, with its head towards the mouth, working its wings vigorously and endeavouring to escape. The result was always the same. The fly succeeded, after several attempts, in reaching the wider open space at the top of the tube, but was stopped by the uppermost ring of hairs. At the next attempt, however, it forced its way through the mouth and flew off. It is probable that, in such cases, the fly had never gone as far as the bulb. The hairs in the tube were in all cases uninjured.

In addition to the obstacles furnished by the hairs, other features of the flower assist in keeping the flies imprisoned. Light enters the bulb through the translucent window area at the apex, and consequently the flies congregate at the top of the bulb, between the wall and the gynostegium, endeavouring to escape in that direction. The darker anterior wall of the bulb may possibly have some influence in keeping the flies away from the inner end of the tube ; if the bulb were uniformly coloured, the anterior side would appear the lighter, as it faces the light and the wall is thin.

On the other hand, the flies are attracted to the tube side of the bulb by the moist zone (Plate I., fig. 5) which extends over the opening, for this zone provides them with food of some description. When the flower is cut open, the smaller flies may be found sucking at this zone, and they will remain there for some seconds before escaping. Some even return to feed there when opened flowers are left on the table. Again, when the bulb has been cut in order to pollinate the flower, and the outer part of the flower left hanging half severed, flies will enter the bulb directly through the opening, not *viâ* the tube, and begin to feed on the zone in question. Ule has made similar observations on the corresponding food areas in *Aristolochia elegans* and *A. brasiliensis.*

The flies continue to enter the flower throughout the day, and no alteration is observable before night-fall. At daybreak next morning, however, several changes are to be noted. The wings of the flower have lost their marginal curvature, and are now flat, with broadly rounded ends (Plate I., fig. 16) ;

by that it is usually possible to distinguish the previous day's flowers from those which have just opened, though in wet weather this change may be delayed. The position of the flower is also changed; on the first day, the bulb hangs obliquely, and the mouth is nearly horizontal, but on the second day the bulb hangs more vertically and the mouth in consequence, assumes an oblique position; this change is brought about by a downward curvature of the upper part of the rigid stalk, *i.e.*, in the ovary. The colour of the flower also alters, the deep coloration of the anterior side of the bulb and of the tube fading to some extent. There is no measurable alteration in the dimensions of the flower or in the curvature of the tube.

It may be noted that the horizontal position of the mouth is disadvantageous, in that rain-water enters and collects in the tube.

At the close of the first day, the gynostegium appears unchanged. The fillet may have begun to shrink, but its general shape is unaltered, and the anthers have not opened. During the night, the foot lengthens slightly, the fillet shrinks and curves backwards, and the next morning the lobes bend inwards until they meet, leaving only a small central hole (Plate I., fig. 9). The anthers open before the gynostegium is completely closed.

If a flower is enclosed in a bag, so that flies cannot visit it, it will be found that, in dry weather, the pollen does not fall freely into the bulb, but remains adherent along the lines of the anthers, where it persists until the flower falls about three days after opening. In wet weather, however, some of the pollen will be found on the wall of the bulb, soon after the anthers have dehisced. In the latter case, it is scattered for a short distance beyond the gynostegium on the lower side of the bulb, but, as the bulb occupies an oblique position, it does not fall into the lower part. One peculiar feature is the occurrence of pollen, in this case, on the wall of the bulb opposite each anther, even on the upper side, and this suggests that the pollen is forcibly expelled from the anthers (compare *Aristolochia elegans*).

In either case, as the flies congregate at the window area, between the wall of the bulb and the gynostegium, they receive or rub off, the bulk of the pollen on their backs. In general, they carry it away in a thick covering on the back of the thorax, as is easily seen in the case of the larger species, *e.g.*, *Sarcophaga*, *Pycnosoma*, &c. No doubt at the same time the flies cause pollen to fall on others which may be present in the lower part of the bulb; scattered pollen grains have been observed on *Lonchæa* sp. But the pollen is not simply dusted over the flies which happen to be imprisoned in the flower. The majority of the flies carry their load of pollen in a position where they are unable to rid themselves of it.

At 6 A.M. on the second day, the lobes of the gynostegium are in process of curling over, and have met along their sides, leaving a star-shaped hole in the centre. The anthers are then open and the pollen free. The closure of the lobes is complete by 7 A.M.

The hairs begin to wither between 7 and 8 A.M. on the second day. Those at the inner end and in the tube wither first; the marginal ring at the mouth may persist for some time later. The flies emerge before the hairs have all withered. The following observations were all made on the same morning :—

Flower A: 8 A.M. First fly emerging; *Sarcophaga* sp.; stopped by the marginal ring of hairs. Caught and examined; did not bear any pollen grains.

Flower B: 8.5 A.M. One *Lonchæa* emerged, sat on the edge of the mouth and cleaned itself. 8.17; two more *Lonchæa* attempting to crawl out were pushed back forcibly by the marginal hairs and fell down the tube. 8.30; another *Lonchæa* crawling up the tube; the two previous not yet escaped. 8.31; one escaped. 8.35; a *Sarcophaga* emerged, back of thorax covered with pollen; also another *Lonchæa*. 8.38; another *Lonchæa* crawled nearly to the mouth and then flew out; one of the 8.30 group still trying to crawl up. 8.40: another *Sarcophaga;* back of thorax covered with pollen; settled on a leaf and cleaned itself but did not reach the pollen on the thorax; afterwards settled on my hands. 8.44; the 8.30 *Lonchæa* escaped; wings of B now curling up. Flower gathered 9 A.M.; no flies left in.

Flower C: 8.15 A.M.; one *Lonchæa* emerging; climbed up to the outer ring and fell back; cleaned itself; at the next attempt found a place where the hairs had withered, and flew away. 8.25 A.M., an Anthomyid emerged. 8.44; wings curling. 8.52; another *Lonchæa* escaped. 8.53; a medium-sized fly, with pollen on thorax. 9.0; a *Lonchæa* and a *Sarcophaga* emerged, the latter with pollen on the thorax.

Flower D: 8.30; two minute flies emerged. 8.34; one *Lonchæa*. 8.46; another *Lonchæa* struggling in the tube.

The small flies generally crawl up to the mouth, and, if the marginal hairs have not withered, they may be thrown back into the tube. But others, emerging at the same time, may be more fortunate in finding a place where the hairs are withering, and may escape at the first attempt. They appear to escape the more easily when they attempt to do so at the lowest point of the mouth. Having passed the marginal ring of hairs, they either fly off, or sit on the edge of the mouth and clean themselves. They appear to have some difficulty in gaining a foot-hold on the smooth rim of the mouth. On the other hand, the larger flies crawl to the upper part of the tube and then fly out. They frequently alight on a neighbouring leaf and there clean off the pollen as far as possible. They are not normally active on emergence, and do not take long flights.

After the flies have emerged, or during the period of emergence, the wings begin to curl over towards the mouth. The glandular hairs now appear dull. The curling continues until the wings nearly meet, but in wet weather this may be retarded. The withered flower usually falls on the third day.

In very dry weather, the changes in the flower may be accelerated. After a period of drought extending over five weeks, the wings of the flowers flattened out at about 6 P.M., on the first day, and the hairs withered and the flies escaped at 7 A.M. the following morning.

In February, 1920, during a prolonged drought, flies were seen to emerge from two flowers on the first day between 5.45 and 6.15 P.M. The hairs had not then withered, but they were not normally rigid. The wings of the flowers were still in the first day position and the pollen had not been liberated. Four or five flies, out of a total of over twenty, escaped from each flower, and these were all the smaller species. The larger species did not attempt to escape.

On the day that observations were made on the emergence of the flies (p. 10), two of the previous day's flowers were plugged with cotton wool at 7 A.M., and were gathered and examined at 9 A.M. One of these contained two *Sarcophaga* and seven *Lonchæa ;* the former bore a thick covering of pollen on the back of the thorax, while six of the latter bore pollen grains adhering generally to hairs on the thorax; these flies were all in the bulb. The second flower contained five *Sarcophaga*, three Anthomyids, and one *Lonchæa ;* the first eight bore the usual coating of pollen on the thorax, while the *Lonchæa* bore pollen grains on its head ; these flies were in the tube. This experiment has been repeated on several occasions, and it is always possible to obtain in this way flies which bear pollen.

The foregoing observations show that the flies do receive pollen while imprisoned in the bulb, and that they carry it away when released from the flowers. If they enter another flower they will naturally fly up to the window, and those which bear pollen on the thorax will consequently deposit it upon the stigma. The translucent window area is a device for causing the flies to seek the neighbourhood of the gynostegium immediately they enter.

Five flowers which had opened in the morning were gathered at 4.30 P.M., placed in a killing bottle, and examined immediately. No flowers had been gathered during the previous six days, and it was known that flies bearing pollen had escaped from the previous day's flowers that morning. One flower contained 14 flies, including nine *Lonchæa* and one *Sarcophaga ;* another contained 4 flies, including two *Lonchæa,* the third contained 8 flies, consisting of seven *Lonchæa* and one *Sarcophaga ;* the fourth contained 8 flies, viz., six *Lonchæa* and two *Sarcophaga ;* the fifth had 4 flies, viz., three *Lonchæa* and one *Sarcophaga.* The flies and the flowers were examined under a microscope, but no pollen grains were detected on the flies or the gynostegium, or on the wall of the bulb and tube.

As the flowers attract flies as soon as they open (6 A.M.), and the flies imprisoned in the previous day's flowers are not liberated until between 8 and 9 A.M., there seemed to be a possibility that the majority of the flies found in a flower might have entered before 8 A.M., and consequently could not have come from a flower which had liberated its pollen during the previous night. Eight flowers were gathered at 8 A.M. on the day they opened. Five did not contain any insects, and the other three contained one fly each, a minute species, not a *Lonchæa* or a *Sarcophaga*. On another occasion, six recently-opened flowers were gathered at 8 A.M. Four did not contain any flies, one contained a minute species, and another a *Lonchæa*. On a third occasion, eight recently-opened flowers were gathered at 8 A.M. Four did not contain any flies, three contained one each of medium size, and the remaining one three flies, one *Lonchæa* and two minute. On another date, twelve flowers, at the same stage as before, were gathered at 8 A.M.; five did not contain any flies, three contained one *Lonchæa* each, one contained two minute flies, another two minute flies, and the remaining two an Anthomyid each.

The thirty-four flowers gathered at 8 A.M. on their first day contained only nineteen flies in all. As the maximum number of flies found in a single flower is 28, and the average over a series of 500 flowers is 5·4, it would seem a fair deduction that the majority of the flies enter the flowers later in the day, and can therefore have come from a flower which has liberated its pollen during the previous night.

Ten flowers, recently opened, were gathered at 9 A.M. Seven did not contain any flies, one contained a *Lonchæa*, and two each contained a minute species. None of the insects bore any pollen, and there was none on the three gynostegia. On another date three recently-opened flowers were gathered at 9 A.M. Only one contained flies, and that had five, two of which were *Sarcophaga*. There was no pollen on the flies or the gynostegium. On another occasion, eleven recently-opened flowers were gathered at 9.30 A.M. No flowers had been gathered during the previous week. Eight of these contained flies, the number per flower varying from one to eight, with a total of twenty-five. A microscopic examination failed to reveal any pollen on the flies, the gynostegia, or the walls of the flower. In all three instances all the flowers which had opened on the day in question were taken for examination.

Pollen has, however, been found on the gynostegium under more or less abnormal conditions. On one occasion, all flowers of the previous day were plugged with cotton wool at 7 A.M., and were opened and examined at 9 A.M. There were seven flowers, and the total number of living flies in them was forty. The flies were allowed to escape uninjured from the flowers, and all the larger, at least, bore pollen. Preparations were then made for conducting another experiment on the flowers which had opened that morning, and in the course of these it was necessary to cut open the bulbs of several flowers. In one bulb, at 9.15 A.M., an Anthomyid was found, bearing pollen on its back, and on examining the gynostegium pollen grains were found on the gynostegium lobes on one side. The flower was certainly one which had opened that morning, and its anthers were intact. The fly had entered another flower immediately after its liberation, but the case is abnormal in that it had been imprisoned in the previous day's flower, probably an hour longer than it would have been under natural conditions. All the other recently-opened flowers, sixteen, were immediately cut off and examined. They contained only seven flies altogether, and none of the flies bore any pollen, nor was any pollen observable on the stigmas.

The foregoing observations were made on an isolated plant. In 1922, two plants, of different clones, were grown together near the laboratory, and flowered at the same time. On casually gathering, at 11 A.M., a flower which had opened that morning, it was found to contain a *Sarcophaga* which bore pollen on the thorax, thus demonstrating that the flies do convey pollen from one flower to another under natural conditions. But it is noteworthy that this was observed only when plants of two strains which differ slightly from one another (see p. 17) were grown side by side. Experiments to ascertain whether flies which had been imprisoned in the flowers of the one strain exhibited a preference for those of the other strain were inconclusive.

Aristolochia ridicula had not been known to produce fruit in Ceylon prior to the experiments here recorded. It was introduced in 1888, with other species, by Trimen, and capsules of those which fruited were placed in the herbarium by him as they appeared. But there is no fruit of *Aristolochia ridicula* among the herbarium specimens at Peradeniya. Further, a plant in my garden which flowers freely had not borne any fruits during the thirteen years I had known it.

To ascertain whether it was possible to obtain fruits of *Aristolochia ridicula* in Ceylon, flowers were artificially pollinated with pollen from the same plant. The tubes of seven freshly-opened flowers were blocked with a plug of cotton wool at 7 A.M. At 9 A.M. an incision was made in the bulb, and pollen applied to the gynostegium by means of a camel-hair brush. A plug of cotton wool was then placed in the bulb, so that flies could not visit the stigma. The pollen was obtained from flowers which had contained flies, after the latter had escaped. The day was moderately fine, with showers at intervals, and the injured flowers did not wither before those which were not injured. No fruit was developed; the ovaries dried up and withered in the usual manner.

The quantity of pollen available in the foregoing experiment was small, and to obtain a larger supply the following modification was adopted. Four flowers, recently opened, were plugged at 7.30 A.M. On the following day twelve flowers were plugged at 7 A.M. and pollinated at 8 A.M., with pollen from the four flowers plugged the previous day. Pollen was available in quantity, as the flowers of the previous day had not been visited by insects. Incisions were made into the bulb as on the previous occasion, and the gynostegium subsequently protected with cotton wool in the same way. Rain fell nearly all the day. Ten days later, all the ovaries had withered.

As there seemed to be a possibility that successful pollination might depend on some stimulus caused by the presence of flies, the transfer of pollen was effected in the following manner. Flowers which had opened on the day of the experiment, and others which had opened on the previous day, were plugged at 7 A.M. If any flies were present in the former, they could not have carried any pollen, while the flies in the latter would be covered with the pollen which had been liberated that morning. At 9 A.M. the previous day's flowers, six in number, were gathered, and, by careful manœuvring, the flies in them were made to enter the flowers which had recently opened. Seven flowers were treated in that way. In five cases, large flies, which bore an abundance of pollen on the thorax, were seen to pass down the tube, while in the two others only *Lonchæa* were transferred. The cotton wool plugs were replaced after the operation. The result of this experiment was the same as in the previous ones, the ovaries withering within twelve days.

The foregoing experiments were done on a plant growing in my bungalow garden. Further trials were next made with pollen from a plant in the Botanic Gardens, about half a mile away. Four flowers on the plant in the Botanic Gardens were plugged at 8.30 A.M. on the day they opened; as it happened, they already contained some flies. On the following day four flowers which had opened that morning on the bungalow plant were plugged at 7 A.M., and at 9 A.M. these were pollinated with pollen from the flowers which had been plugged on the previous day on the Botanic Gardens plant. Two of these were pollinated by cutting open the bulb and applying the pollen with a brush, the other two by transferring flies which were evidently covered with pollen. The flowers were protected from the visits of other flies in the same way as before. During the operations some flies escaped, but two flies were transferred to one flower, and four to the other. Seven days later it was evident that the experiment had been successful in three cases out of the four, viz., in both the flowers into which flies had been transferred, and in one of those pollinated artificially. Moreover, another flower of the same day also produced fruit, having evidently been pollinated by one or more of the flies which escaped.

The flowers were pollinated on December 12, 1918. On January 10, 1919, one of the fruits, though still green, began to split at the top and along the stalk, and three days later, the same happened in two others. The splitting, however, occurred between the loculi, and, the weather being fine, it did not affect the subsequent maturing of the fruits. The first was ripe on March 30, and the other three on April 8, 1919. In 1922, when plants of these two strains were grown side by side, fruits were produced naturally.

The plant in the Botanic Gardens, like that at the bungalow, had never borne any fruit. It would appear, therefore, that *Aristolochia ridicula* is self-sterile.

The Botanic Gardens plant, though evidently *Aristolochia ridicula*, differs from the plant at my bungalow in several details. The wings of the flower are more deeply coloured, so much so that they sometimes appear almost black, and the coloration of the bulb and tube is also more intense. The glands on the wings are gradually inflated at the tips, not pin-headed as in the bungalow plant. The whole flower is smaller, the dimensions of the two being, in centimetres :

	Botanic Gardens.	Bungalow.
Length of wing	1·8 ..	2·5
Apex of bulb to upper edge of mouth	3·0 ..	3·5
Mouth	1·6 × 1	2·0 × 1·1

The pollen grains of the Botanic Gardens plant are spherical, 50–60 μ diameter, with a wall 4–5 μ thick; those of the bungalow plant are 54–65 μ diameter, with a wall 5–8 μ thick. In general appearance they are identical, being minutely rugose, with an irregular viscid outer layer when moist, which becomes minutely lacunose, or obscurely and irregularly netted with broad bands, when dry. There is thus no marked difference between the pollen grains. The Botanic Gardens plant appears to retain its small flowers under all conditions of cultivation, and plants propagated from it by cuttings are also small-flowered. But the difference between the two plants is hardly sufficient to constitute dimorphism.

Why do the flies enter the flower? They may be seen in the neighbourhood of the flowers as soon as the latter have opened, even before expansion is completed, and some of the larger species are generally to be found on the plant during the day, resting on the broad leaves. But they do not exhibit any eagerness to approach the flowers, and one never observes a number flying round the mouth of the flower as in *A. gigas* or *A. elegans*. They will sit on a leaf motionless for a quarter of an hour and then fly away, or if they alight on the face of the flower they will crawl over the glandular hairs and round the mouth without making any attempt to enter.

It has already been shown that flowers from which the face has been cut away do not attract as many flies as those which are intact, and it is certain that the moist zone above the inner end of the tube provides the captive flies with some food. It might be supposed, therefore, that flies which had been attracted to the flower by some odour from the glands on the face were enticed down the tube by the odour of the food substance in the bulb. With that idea in mind, the following experiment was carried out.

The anterior part of the flower, *i.e.*, the face and tube, was cut off across the tube just above the junction of the latter with the bulb, and the severed portion was fixed with cotton wool in a glass tube, the sides of which were darkened with black paper placed inside, the base being left clear. Owing to the wet weather, it was not practicable to put the paper on the outside of the tube. Three flowers were treated in that way, and three others similarly, but cut so that the part fixed in the glass tube included the anterior portion of the bulb, *i.e.*, the part containing the moist food zone. These tubes were then fastened with copper wire in pairs to the bush over which the *Aristolochia* was growing, and arranged so that the mouths of the flowers took up the normal horizontal position. This was done at 8.30 A.M., nine flowers which had opened that day being left untreated. No flowers had been gathered the previous day. The morning was showery, rain predominating, and the severed flowers did not show signs of withering until noon. The three tubes of the first series then contained one fly only, of medium size; those of the second series, which included the food area of the bulb, contained one minute fly, one *Sarcophaga*, and one minute and one medium fly, respectively. The nine unmutilated flowers, gathered at the same time, yielded 5, 4, 6, 8, 0, 1, 2, 1, 1 flies respectively. The three bulbs of the flowers of the first series, which had been left intact on the plant and had their entrances protected by hairs, each contained one minute fly.

The experiment was repeated a week later, the only modification being that the paper was omitted. It was begun at 9.15 A.M., but the morning being bright and sunny, the flowers had begun to wither at 10.30 A.M. None of the tubes then contained any flies, and the three flowers which had been left as controls only contained 0, 1, 1 flies respectively.

The first of the foregoing experiments does actually show a greater number of flies in those tubes in which the severed part of the flower included the food area, but the numbers are too small to afford any basis for definite conclusions. No further experiments were carried out on these lines as it was evident from other observations on the behaviour of the flies that the idea which had prompted them was incorrect.

No instance has yet been observed in which flies which have alighted on the face of the flower have crawled down the tube. Invariably, after walking over the face for a short time, they have flown away. In all the cases of actual entry observed, the fly, if a large one, has flown straight into the mouth, or, if a small one, has alighted on the marginal hairs and slipped in. According to these observations, the mouth is simply a pitfall, and the fly only enters the flower by accident, mistaking the white screen of hairs for a solid surface.

Why do the flies emerge from the flowers as soon as the hairs wither? The wall of the bulb appears more transparent on the second day than on the first, owing to the fading of the purple colour, but the window area is still the most translucent part. But owing to the altered position of the flower and the withering of the hairs, more light enters through the tube and is reflected inwards from its white wall. The mouth of the tube is consequently the most strongly illuminated area, and the flies will naturally be attracted to it. Some observations, however, appeared to indicate that the problem was not quite so simple as it seemed, and that other factors might be operative. It was frequently noted that, when flowers a day old were plugged with cotton wool in the early morning and opened after the hairs had withered, many of the flies were found in the tube, some of them, more especially the smaller, being wedged between the wall and the plug, in an evident endeavour to escape, though the mouth was completely darkened. It was inferred from this that there was a possibility that the flower might, when withering, emit some odour which drove the flies out. In the case of *Aristolochia gigas*, in Ceylon, many of the flies do not escape, but die in the flower on the second day. To elucidate this point, the following experiments were carried out.

Seven flowers of the previous day were plugged at 7 A.M. At 9 A.M. they were gathered, one at a time, each flower being gripped by forceps just above the bulb, removed from the plant, and the bulb and tube examined separately. The following results were obtained :—

Flower Number.	In Bulb.		In Tube.	
1	1 *Sarcophaga* 1 *Lonchæa*	alive	1 *Lonchæa*, alive	
2	2 *Lonchæa*, alive		1 *Lonchæa* 1 medium size	alive
3	1 *Sarcophaga* 1 *Lonchæa* 1 medium size 1 ichneumonid	alive	1 *Sarcophaga*, alive	
4	1 ant, alive		1 Anthomyid 1 *Sarcophaga* 2 *Lonchæa*	alive
5	3 *Lonchæa* 1 Anthomyid 1 *Sarcophaga*	alive	1 *Sarcophaga* 1 *Lonchæa*	alive
6	3 *Sarcophaga* 3 *Lonchæa*	alive		
	1 *Sarcophaga* 1 Anthomyid	dead	—	
7	3 *Sarcophaga* 1 *Lonchæa*	alive	1 medium size 3 *Lonchæa* 1 minute	alive

The flowers have been arranged in order of population. The only dead flies occurred in the flower which contained 8 flies ; this was not the maximum number of flies, but certainly the maximum mass. With regard to the distribution of the insects, 26 were found in the bulbs and 15 in the tubes. There was an excess of flies in the tube in two cases only. The duration of their imprisonment was at most one hour longer than the normal.

On another occasion flowers were plugged at 5.30 P.M. on the first day, and examined at 1 P.M on the second, with the following results :—

Flower Number.	In Bulb.	In Tube.
1	1 ant, dead	—
2	1 *Sarcophaga*, active	—
3	1 *Lonchæa*, dead	—
4	2 small, active	—
5	1 minute, active	1 minute, active
6	3 *Sarcophaga*, active	—
7	2 *Sarcophaga* 1 Anthomyid } active	—
8	1 *Sarcophaga*, active	1 Anthomyid 2 minute } active
9	1 Anthomyid, active 1 *Lonchæa*, dazed	1 medium, dazed
10	3 *Sarcophaga* 1 froghopper } active	1 *Lonchæa*, dead 1 small, dazed
11	3 *Sarcophaga* 1 Anthomyid } dazed	1 Anthomyid, active 1 *Lonchæa*, active 1 *Lonchæa*, dazed

The total number of insects was small, probably because the first day was continuously wet. Of the thirty-three found, only ten were in the tubes, and in only one case did the number in the tube exceed that in the bulb. As the number of flies increased, they became less active, but of the three dead insects found, two occurred in flowers which contained only one insect each. They had been imprisoned four to five hours beyond the normal time, but the flowers had been closed for nearly twenty hours.

Flowers were next plugged at 7 A.M. on the second day and examined at 6 P.M. The number and condition of the insects were as follows :—

Flower Number.	In Bulb.	In Tube.
1	1 *Sarcophaga*, active 1 *Lonchæa*, active	—
2	1 *Sarcophaga*, active	1 *Lonchæa*, active
3	1 Anthomyid, active	1 *Lonchæa*, dazed
4	1 *Sarcophaga*, active	1 *Sarcophaga*, dead
5	1 *Sarcophaga*, active 1 minute, active	1 minute, active
6	1 Anthomyid, active	1 *Sarcophaga*, active 1 minute, active

Flower Number.	In Bulb.	In Tube.
7	1 ant, active	1 ant, active
	1 minute, active	
8	1 *Lonchæa*, active	1 *Sarcophaga*, dead
	1 *Sarcophaga*, dead	
9	1 Anthomyid, active	1 minute, dazed
	1 *Lonchæa*, active	
	1 medium, nearly dead	
10	1 *Sarcophaga*, active	2 *Lonchæa*, active
	1 *Sarcophaga*, dead	
11	1 *Sarcophaga*, active	2 *Lonchæa*, active
	1 medium, active	
	1 *Lonchæa*, active	
12	1 *Sarcophaga*, active	1 *Sarcophaga*, active
	1 Anthomyid, active	1 *Lonchæa*, active
		1 *Sarcophaga*, dead
		1 medium, dead
		1 *Lonchæa*, dead
13	2 *Lonchæa*, active	2 *Lonchæa*, active
		2 Anthomyids, nearly dead
		1 Anthomyid, dead
14	1 Anthomyid, active	1 minute, active
	1 medium, active	3 *Lonchæa*, active
		1 minute, dead
		1 *Lonchæa*, dead

Of the 55 insects found, 29 were in the tube. Ten flies were dead, five of these being the large *Sarcophaga*. They had been imprisoned nine hours longer than usual, and the flowers had been closed for eleven hours.

As a final test, the flowers were plugged at 6.30 A.M. on the second day, and examined at 8 A.M. on the third day. As a rule, it is not possible to leave them longer, because they then begin to fall off. The following observations were made :—

Flower Number.	In Bulb.	In Tube.
1	1 froghopper, alive	—
	1 *Sarcophaga*, dead	
2	1 *Sarcophaga*, alive	—
	1 froghopper, alive	
	1 *Sarcophaga*, dead	
3	1 *Sarcophaga*, dead	2 *Sarcophaga*, dead
4	1 *Sarcophaga*, alive	1 *Lonchæa*, alive
		1 *Sarcophaga*, alive
		1 *Sarcophaga*, dead
5	1 *Sarcophaga*, alive	1 *Lonchæa*, alive
	1 small, alive	1 *Sarcophaga*, dead

Flower Number.	In Bulb.	In Tube.
6	2 *Lonchæa*, alive	2 *Lonchæa*, alive
	1 ant, alive	
7	2 *Sarcophaga*, alive	1 *Sarcophaga*, alive
	1 medium, alive	1 *Sarcophaga*, dead
8	2 *Sarcophaga*, alive	1 *Lonchæa*, alive
	1 Anthomyid, alive	1 *Lonchæa*, dead
	1 *Lonchæa*, alive	1 medium, dead
9	1 small, dead	1 Anthomyid, dead
		5 *Sarcophaga*, dead
		1 *Lonchæa*, dead

Of the 41 insects found, 21 were in the tubes. Eighteen flies were dead, 13 being the large *Sarcophaga.* They had been imprisoned twenty-four hours beyond the normal, and the flowers had been closed for over twenty-five hours.

The results of the foregoing experiments are summarized in the following table :—

Experiment.	Number of Flowers.	Insects in Bulb.	Insects in Tube.	Hours imprisoned beyond Normal.	Hours Flower Closed.	Flies Dead.
1	7	26	15	1	2	2
2	11	23	10	4–5	20	3
3	14	26	29	9	11	10
4	9	20	21	24	25	18

It will be evident that the recorded observations do not bear out the supposition that the flies congregate especially in the tube if the mouth of the flower is plugged. Nor do they afford any evidence in support of the idea that the insects, under normal conditions, are driven out of the flower by some emanation, or die if they do not escape. Though there are exceptions, the dead flies are found in the flowers which contain the greatest mass of insects, and in general it is the larger flies which die. It would appear probable that death is due merely to suffocation, or starvation.

We have therefore to fall back on the supposition that the flies escape because they are attracted to the tube by the influx of light when the hairs wither, an explanation which is somewhat unconvincing when other flowers are taken into consideration.

When placed in a strong cyanide bottle, the bulbs of all the species of *Aristolochia* cultivated in Ceylon blacken. In *Aristolochia, ridicula*, this blackening ultimately extends over the whole flower, including the gynostegium. In one set of specimens, it was noted that, after flowers collected at 8.30 A.M. had been left for about a quarter of an hour in the cyanide bottle, only one gynostegium was blackened, and that was one which had been pollinated by a fly from a flower of the previous day, gathered by accident at the same time and enclosed with the others in a box. An attempt was made to follow this clue further. Flowers were pollinated at 8 A.M. and gathered at 9 A.M., with others which had opened the same day. The gynostegia blackened very slowly in the cyanide bottle, and the flowers were consequently left in it until 11 A.M. It was then found that in the pollinated flowers the gynostegia were only slightly blackened; in two others, not pollinated and not containing flies, the gynostegium was slightly blackened in one case, and not blackened in the other. The greatest blackening of the gynostegium occurred in a flower which contained five flies (two *Sarcophaga* and three medium), but there was no pollen on the gynostegium or on the flies. From the data, it is not possible to correlate the blackening of the gynostegium with pollination.

Another effect was observed in a weak cyanide bottle which was not strong enough to blacken the flower. Two flowers, one opened that day and another which had opened the previous day, were placed in the bottle at 9 A.M. The hairs in the second flower had withered and the flies had escaped. At 12 noon no change was observable in the younger flower, but in the older flower the wings had lost their pattern and had become a uniform purple-red. The experiment was repeated with the same result. Similar flowers kept in a stronger cyanide bottle for the same period were blackened, but the pattern on the wings was not destroyed.

From May 8 to June 11 the flowers from one plant were gathered daily at about 6 P.M., and the number of flies counted. As the flies were killed by placing the flowers in a cyanide bottle, each day's catch represents a new set of visitors, and consequently the numbers might be expected to be smaller than in an isolated collection. But the average on the first day was 5·1, and on the last day but one, 5. The total number of flowers examined was 504, and the number of flies, 2,731, an average of 5·4 per flower. Forty flowers, or eight per cent., did not contain any flies. The greatest number in any single flower was 28.

Some of the flowers are hidden, or partly hidden, by the leaves. As a rule, these contain the smallest number of flies, but the rule is not universal. Of five flowers (all that were open) gathered on one occasion, two, fully exposed, contained 5 and 6 flies respectively, while three, hidden by the leaves, contained 6, 7, and none.

As has already been shown, few flies enter the flowers before 8 A.M. As might be expected, they do not visit the flowers at night. Nine recently-opened flowers were plugged at 6.15 A.M., and the plugs removed at 6.30 P.M. When collected and examined at 6.15 A.M. next morning, they did not contain any flies. The average is lower in wet weather than in fine. On five wet days 63 flowers yielded 198 flies—an average of 3—and 10, or sixteen per cent., did not contain any. On the other hand, the average has risen to 11 on a bright sunny day (136 flies in 12 flowers). There is also a difference in the relative numbers of the species which visit the flowers in wet and fine weather. On fine days *Lonchæa* usually predominates, and may constitute eighty-seven per cent. of the total, *e.g.*, 105 out of 120, 105 out of 128, 69 out of 89. In wet weather the large *Sarcophaga* forms the greater percentage: thus, on two wet days 22 flowers gave 56 flies, of which 26 were *Sarcophaga* and only 8 *Lonchæa*. Again, nine flowers gathered at 12 noon on a wet day contained 30 flies, of which 18 were *Sarcophaga* and 4 *Lonchæa*.

So little is known of the Diptera of the tropics that it has not been found possible to obtain identifications of the majority of the species found in the *Aristolochia* flowers. In a collection of 2,546 insects taken from the flowers of *Aristolochia ridicula*, there were 64 species, but 49 of these were represented by less than ten individuals each, 28 of them by a single specimen. Among these latter, which may be regarded as accidental visitors, were *Stomatorrhina discolor* F. (1), *Bactrocera ferruginea* F. (1), *Bactrocera cucurbitæ* Coq. (2), *Ditoneus scabripennis* Mots. (1), *Coptosoma siamica* Wlk. (2), *Plateros dispellens* Walk. (1), *Formicomus obscurus* Pic. (1), *Formicomus brahminus* Laf. (1).

Lonchæa spp. were present to the number of 1,586, or 62 per cent.; two species occurred, but chiefly *Lonchæa aurea* Moq.

Sarcophaga sp. was represented by 197 examples, or about 8 per cent. The relative numbers of these two genera indicate that the collection was made during fine weather.

Other species which have been identified are *Cestoplectus intuens* Lamb. (41), *Campsocera mutata* Beck. (53), *Aphiochæta* sp. (45), *Hippelates ocellatus* Lamb. (124), *Hippelates nigricornis* Thoms. var. *bilineatus* Meij. (9), *Hippelates* sp. (13), *Musca cingalaisina* Big. (number not determined), *Anthomyia bisetosa* Thoms. (48).

Unidentified species were present in the numbers 88, 59, 48, 48, 35, 30, 23, respectively. The first, third, fourth, and fifth of these were *Anthomyidæ*.

SUMMARY.

The flower of *Aristolochia ridicula* opens at day break, and the stigmatic area is then receptive. During the following night the fillet shrinks and curves back, the lobes of the gynostegium begin to close, and the pollen is liberated.

Flies enter the flower as soon as it opens, but are unable to escape until between 8 and 9 A.M. on the following day, when the hinged hairs wither.

The full series of changes in the flower occupies about twenty-seven hours, and the flies are not liberated from one day's flowers until after those of the next day have opened.

The window area at the apex of the bulb ensures that the flies which enter the flower will seek the neighbourhood of the gynostegium. Consequently, when the pollen is liberated, they receive it on their backs, and if they enter another flower they will leave it on the stigmatic surface, by occupying the same position at the window area.

Two areas symmetrically situated above the inner end of the tube provide food for the imprisoned flies.

In Ceylon, *Aristolochia ridicula* is visited by a large number of species of flies, but *Lonchæa* predominates in fine weather, and *Sarcophaga* in wet weather.

Aristolochia ridicula is self-sterile.

There is no obvious reason why flies should enter the flower. The mouth, almost covered by hinged hairs, appears to act as a pitfall.

Aristolochia elegans Mast.

The species cultivated under this name at Peradeniya agrees with the plant figured in Curtis's Botanical Magazine, Plate 6,909.

In the young bud the flower is straight. As it increases in size, the tube and limb turn at right angles to the bulb, and later make another right-angled turn which brings the two parts parallel. As in the case of other hooded species, *e.g.*, *Aristolochia gigas*, the two halves of the limb or hood, though united, as usual, by their edges in the unexpanded flower, are not closely applied to one another, but form an inflated balloon-like structure. In *A. elegans*, the suture is marked by a longitudinal groove.

The flower stalk (*i.e.*, the combined stalk and ovary), about 9 cm. long, hangs vertically downwards, with a slight backward curve below. It expands into a narrow, green disc which is usually sunk in a depression in the apex of the bulb, but may be a little distance above it. The bulb is oval, about 2·75 cm. long and 1·5 cm. diameter, truncate above and slightly contracted towards the apex. It hangs vertically (Plate II., fig. 6).

The bulb merges into the tube, which leaves it on the lower third of the anterior face and curves upwards almost parallel to it, the wall of the bulb being slightly invaginated above the bend. On the upper part of this invaginated area are two lunate depressions, transversely and symmetrically situated. The tube is about 6 mm. in diameter and cylindrical below, expanding slightly above and becoming somewhat compressed from front to back. The exterior of the bulb and tube are pale green and smooth. Three strong veins run longitudinally down the anterior face of the bulb, and numerous others, less conspicuous, down the remaining part of the wall. The depressed areas referred to above are situated one on each of the anterior sectors, and correspond with the swellings found in the same position in *A. indica*. The veins follow the course of the tube to the hood, where the three previously mentioned, with another on either side, form five prominent dorsal ribs which keep the hood rigid.

The wall of the tube and bulb is thick and fleshy. At the apex of the bulb it attains a thickness of 3 mm., but elsewhere it is about 1 mm. Owing to the thickness of the wall, the window area is not visible externally.

The tube ascends to about two-thirds the height of the bulb, and then expands into the hood or face. The latter is concave, about 6 cm. high, 4·5 cm. broad, and 2 cm. deep. Its margin is incised at the highest and lowest points. The mouth of the tube is situated in the lower part of the face and is pale greenish-yellow. This is surrounded above by a broad, crescentic, red-purple patch, which is continued in a fringe of short streaks towards the greenish-yellow mouth. The remainder of the hood is covered with red-purple, branching lines, or irregularly dendritic spots arranged more or less in radial lines, crowded together on a pale yellow ground.

The hinged hairs begin just below the yellow patch at the posterior side of the mouth, but on the anterior side a few are to be found on the hood just outside the lip of the tube. They are continued down the pale green, inner wall of the tube, but are scattered, and not longer than 0·8 mm. In structure and position they agree with those of *A. ridicula.*

Within the bulb, the invaginated area of the wall is smooth and thickened. This smooth zone is about 5 mm. broad above the entrance to the tube, but thins off down either side, and is continued as a narrow zone round below. Above the thickened zone are two symmetrically-placed lunate or semi-oval swellings, corresponding with the depressions seen from the exterior : they are densely covered with minute adpressed hairs, and are at first white, but become purplish when old. These swellings are the food areas (Plate II., fig 7). The apex of the bulb is occupied by the window area, which is bordered by a broad purple-red zone, well defined at its upper edge, but fading away below. The remainder of the wall of the bulb is pale green, and covered with long, decumbent, woolly hairs.

The flower opens before daybreak. On July 20 the flowers were half-expanded at 5.25 A.M., that is, dehiscence was complete, and the sides had curved back half way to their final position. Sunrise on that date was at 6·2, and at

5.25 A.M., it was barely possible to distinguish the flowers without artificial light. The flower was fully expanded at 6 A.M.

Flies begin to visit the flower as soon as it is light, and numbers may be seen flying round the mouth of the tube within the hood at any time during the day. All the flies which visit the flower are minute. The flower has no appreciable scent, and the larger flies are not attracted to it. But that the flies are attracted by some odour, and not merely by the colour and appearance, is evident from the fact that when a flower has been bagged prior to opening, flies and ants will be found on the bag as soon as it opens, though the bag may be so small that the sides of the face barely separate. Sometimes dozens of ants will be found on the bag on the morning the flower opens, though they do not attempt to visit the flower before it opens.

Under normal conditions, some flies alight on the concave surface of the hood above the mouth, and after walking about for a few moments dive into the tube. At first sight, one has the impression that they fall in, but the movement is too rapid for that. It would appear that in the course of their wanderings over the hood they press back the hinged hairs, and are thrown into the tube by the recoil of the latter, in the same way as the smaller flies are thrown back down the tube of *Aristolochia ridicula* when they try to escape before the hairs near the mouth have withered. They fall about half way down the tube, and may then either proceed into the bulb or fly back out of the flower. Other flies alight on the lip and walk over into the tube, while many fly straight in. Very many which enter the tube and proceed at least half way down the hairy surface struggle out again, some climbing over the lip, and others flying out.

During the following night the pollen is liberated. In dry weather, if the flower has been bagged, the pollen remains adherent to the lines of the anthers until the flower falls, but in wet weather it is found on the wall of the bulb round the gynostegium. It is not found, as a rule, in the lower part of the bulb in a bagged flower, although the bulb is vertical; and this suggests that the pollen is forcibly ejected from the anthers. The hairs in the tube wither about 8 A.M. the next morning, and flies have been seen emerging then, but, as a rule, they escape soon after day break, although the hairs have not then withered. Flowers have been found to be empty at 6.45 A.M., before the hairs had withered, though there was abundant evidence that flies had been present and in some cases eggs had been laid in the bulb.

The gynostegium is not closed at the time the pollen is liberated. The fillet has partly curved back, but its edge is not withered, and the position of the teeth is practically unchanged. In this species, the outer faces of the teeth of the gynostegium do not become plane, and the gynostegium never closes completely.

By noon on the second day the sides of the hood have curled inwards, and the flower appears to be withering. It recovers, however, during the second night. On the morning of the third day the hood is again rigid, and the flower normally expanded. It finally collapses by noon on the third day. In very wet weather this sequence may be modified, and the flower may remain continuously rigid until it falls. The flower does not repel flies on the second day. Flies bearing pollen have been seen endeavouring to visit a bagged flower on the second morning ; and others have been seen within the hood of a fallen flower, which had remained expanded, on the fourth morning.

Ule, who examined *Aristolochia elegans* in Brazil—and evidently the same species as that cultivated under that name at Peradeniya—stated that when the anthers are ripe the bore of the tube increases from 1·5 mm. to 2·5 mm. By that he perhaps meant that the hairs, which previously obstructed the passage, withered. In Ceylon, the diameter of the tube does not alter ; it is about 6 mm. diameter externally and 4 mm. diameter internally. But as the hairs are about 0·8 mm. long, the free passage increases from 2·5 to 4 mm. when the hairs have withered.

Flies are found in the flower in comparatively large numbers, and it is generally possible to find pollen on the lobes of the gynostegium, on the first day the flower is open, before the pollen of that flower has been liberated. Flowers gathered at 5 P.M. on the day of opening gave the following results :—

November 6, 1918. . Fine morning ; rain in afternoon ; one flower examined : contained 70 flies and 1 ant ; hairs not withered ; pollen not liberated ; pollen present on the outer surface of the teeth of the gynostegium.

November 7, 1918. . Fine morning ; rain in afternoon ; one flower examined : 101 flies ; condition as in the previous case.

November 8, 1918. . Fine morning ; rain in afternoon ; three flowers examined : 57, 47, and 2 flies respectively ; pollen on gynostegium lobes of the last two.

November 12, 1918. . Fine day ; five flowers examined : 128, 50, 43, 31 flies in four flowers respectively, and 17 ants in the fifth ; pollen on gynostegium lobes of all but the one containing 31 flies.

There can be no doubt that, in the case of *Aristolochia elegans* pollen is transferred from one flower to another. It would seem probable from the observation last quoted that the transference may be effected by ants ; in the case of the flower which contained 17 ants, pollen was present on the lobes of the gynostegium and there were no remains of flies in the flower. It is, however, possible that flies might have entered the flower and escaped again.

The ants found in the flowers of *Aristolochia elegans* at Peradeniya are usually a small black species, *Technomyrmex albipes* Smith, which is commonly found on shrubs and trees in that district. But a small brown ant has been seen in large numbers endeavouring to enter a bagged flower. The former of these devours the flies in the flower.

The flies which frequent *Aristolochia elegans* at Peradeniya are nearly all the same species. In a collection of 504 flies there were only three species—502 examples of one, and a single example of each of two others. The principal species is an *Aphiochæta.*

At first sight, *Aristolochia elegans* appears to afford an excellent example of the *Aristolochia* type of adaptation ot insect visitors. The flower captures flies during the whole of the first day on which the stigma is receptive, and liberates them on the morning of the second day after the anthers have dehisced. Even in a foreign country it finds itself adapted practically to one insect, and pollen-transference is readily demonstrable. It produces seed in abundance, so much so that in some cases every node on a stem bears a fruit capsule.

Further observation, however, shows that its adaptation is very incomplete, when compared with the flowers of other species of *Aristolochia*, especially as regards the imprisonment of the flies. It has already been noted by Ule in Brazil that the flies can escape from the flowers before the hairs wither; he found that when the flowers were laid on a dish prior to examination, the flies emerged, and as that could not be due to pressure on the bulb, owing to the thickness of the wall, he concluded that the hinged hairs are not an absolute hindrance in this case.

Exactly the same is true in Ceylon. When the flowers are disturbed in course of gathering them, the flies immediately begin to emerge, and it is necessary to plug the mouths with cotton wool before gathering them, if it is desired to capture all the flies within the flowers. Tapping the bulb generally causes the flies to come out, but this fails if the flower contains ants as well as flies. The ants congregate in the lower part of the bulb round the inner end of the tube, and apparently prevent the egress of the flies.

Ule's conclusion is consequently correct, as far as regards the insects which visit and pollinate *Aristolochia elegans* in Ceylon. The hinged hairs in this case do not constitute an absolute barrier, and the flies can emerge at any time. Why they should collect within the flower to the number of over one hundred, and remain there for periods up to twenty-four hours, emerging on the following morning when the hairs in the tube are to all appearance in the same condition as they were on the previous day, cannot at present be explained. The circumstances suggest that there are other changes in the condition of the flower which have not yet been ascertained.

As already stated, the flower of *Aristolochia elegans* will attract flies on the second morning. The suggestion that the flies are driven out of the flower on the second day cannot therefore be upheld. Nor do all the flies die if they are prevented from emerging. When the entrance to a flower has been plugged with cotton wool on the first day, some flies have been found to be alive when the flower fell three days later.

Another abnormal feature in *Aristolochia elegans*, as compared with the other species of *Aristolochia* under observation, is the revival of the flower during the second night. On the third morning the flower appears to be normally expanded and until the interior is examined it cannot be distinguished from one which has opened that morning. Hence flies may visit, and convey pollen into, the old flower, on the third day. This has, however, the advantage that the flies might convey pollen from the old flower to another which had recently opened.

The following instance may afford an illustration of the point raised in the foregoing paragraph. A young plant came into flower on July 17, only one flower opening on that day. Flies were observed to enter the flower in the afternoon, and were seen emerging on the following morning. The flower wilted before noon on the 18th. On the morning of the 19th the second flower on the same stem opened, and the first flower had revived. The first flower did not set fruit, but the second flower did. There was no other plant of *Aristolochia elegans* in bloom in the same garden, but there was one in another garden about a quarter of a mile away. As, however, the two gardens were separated by a dense block of *Hevea* and a row of full-grown *Bombax* trees, and the prevalent winds are at right angles to the line joining the two gardens, it would seem unlikely that pollen had been transferred from one plant to other. It is more probable either that the second flower had been fertilized with pollen a day old from the first flower, or that it had been self-fertilized.

It may be noted that, as a general rule, though not without fairly frequent exceptions, the successive flowers on the same stem of an *Aristolochia*, in those species which bear only one flower at a node, do not open on consecutive days. Generally, two, three, or four days elapse between the opening of successive flowers.

The fruit capsule of the flower which bloomed on July 19 turned black on September 30, and dehisced on October 12. The seeds were planted on October 13 and germinated on November 5, a comparatively rapid germination for an *Aristolochia.* Slow ripening of the fruit and delayed germination of the seed appears to be the more general rule.

Burck, who examined *Aristolochia barbata* in Java, maintained that the flowers of *Aristolochia* were self-fertilized, the imprisoned flies merely transferring pollen from the anthers to the stigma of the same flower ; and in detailing his objections to the theory that the structure of the flower was a device to ensure cross-fertilization, he propounded the query, what happens to the first flower ? As *Aristolochia elegans* fruits abundantly, it appeared to be a suitable species on which to test Burck's views. The following preliminary observations were made :—

Observation 1 : A plant came into flower on July 17, 1918, only one flower opening on that day. Flies were seen to enter the flower on the first day. The flower wilted before noon on the 18th, but revived during the night. On the 19th the second flower opened. The second flower produced a fruit ; the first did not. No other species, except an *Aristolochia ridicula,* were in flower in the same garden. This is the case already referred to above.

Observation 2 : On another plant the first flower similarly did not produce a fruit, while the second did. Owing to my absence the dates of opening of the flowers were not recorded.

The *Aristolochia ridicula* was pruned back on July 10, 1919, all flowering shoots being removed.

Observation 3 : A flower of *Aristolochia elegans* opened on July 22, 1919, and fell during the night of the 24th. Another flower on a second branch of the same plant opened on July 25 and fell on July 28. A third flower on the same branch as the first opened on July 27 and fell on August 2. The first of these produced a fruit, but the second and third did not. There were no other Aristolochias in flower at the time.

Observation 4: A plant came into flower on May 9, 1919. No other flowers of this species were open, and no plants had been in flower for some months previously. The tube was blocked with cotton wool at 5 P.M. The next flower on the same stem opened on May 16 and was similarly treated. The third on the same stem opened on May 27 and was blocked at 6 P.M. in the same way. The first of these produced a fruit, but the other two did not. All the flowers contained flies when blocked.

Observation 5: Two neighbouring plants, A and B, came into flower about the same time, and each bore three consecutive flowers. All the flowers were blocked at 6 P.M. on the day they opened, and were left blocked until they fell, so that no transfer of pollen should be possible. The first flower of A opened on July 12, 1919, and fell on July 15; the second opened on July 16 and fell on July 18; the third opened on July 18 and fell on July 21. The first flower of B opened on July 14 and fell on July 17; the second opened on July 16 and fell on July 18; the third opened on July 18 and fell on July 21. No flowers of this species had opened for several weeks previously. On the morning of the 18th, at 7 A.M., it was found that the second flower on B had been partly eaten by a snail during the night and the plug had been dragged out; it was re-blocked, but all the flies had escaped. All three flowers on B set fruit, but only the first and third on A. It is probable that the third flower on each plant was pollinated by insects from the second flower of B. Some larvæ were found in the second flower of A after it had fallen, but no remains of flies; evidently flies had entered and emerged again on the first day before the flower was blocked, and none were present when the pollen was liberated.

The seeds of the fruit referred to in observation 1 germinated in twenty-four days, but the percentage germination was very poor: this was a case either of self-fertilization or of cross-fertilization from an old flower. The seeds obtained from the fruits recorded under observation 4, and from the first fruit of each plant in observation 5 were sown, but in each case very few germinated; both 4 and 5 were cases of self-fertilization.

Further experiments were carried out in 1921. A plant came into flower on September 21. Only one flower was open on that day, and there were no other plants of that species in flower in the neighbourhood. It was blocked with cotton wool at 4.30 P.M. The second flower opened on September 22, and was similarly treated, while the third opened on September 25 and was blocked at the same hour as the others. All three flowers produced fruits, which ripened in December. The seeds from these were sown on December 22, 1921. Those from the first two fruits began to germinate on January 16, 1922, and those from the third on January 24. In each case, part of the seeds were sown in their natural condition, and part clipped. The clipped seeds germinated about a day later than the unclipped, and the percentage germination was very poor. In the case of the unclipped seeds the percentage germination of those from the second fruit was good, but that of the seeds from the first and third fruits poor.

Another plant came into flower on November 5, 1921, when no other plants of *Aristolochia* were in flower. The first flower was not interfered with ; it fell during the night of November 7 and did not produce a fruit. The second flower opened on November 10 and was blocked with cotton wool at 5.30 P.M. ; this flower produced a fruit which ripened on January 22, 1922. The seeds were sown on January 23 and germinated on March 4, the percentage germination being very good.

Flowers were bagged before they opened and self-pollinated on the second morning after they had opened. Seven flowers were treated in that way. Two were consecutive flowers on the same plant, one a single flower on another plant, the next three, consecutive flowers on a third plant, and the seventh, a single flower on a fourth plant. The pollen was transferred from the anthers to the teeth and cone of the gynostegium by means of a camel-hair brush. Before the operation the tube was blocked with cotton wool, and the flower was re-bagged afterwards until it dropped off. In the case of the first three and the seventh a flap was cut near the apex of the bulb, but in the other three the whole of the flower was cut away, except the apex of the bulb round the gynostegium. No two flowers were pollinated on the same day, the intervals between the pollinations, in the order stated, being 10, 6, 1, 2, 2, 5 days. Two of the first series, viz., the single flowers Nos. 3 and 7, produced fruits, and one of the second series, viz., the third of the three consecutive flowers.

Six flowers, which had been bagged prior to opening, were pollinated on different occasions on the morning the flower opened with pollen from *Aristolochia ridicula* which had been liberated the same morning. No fruits were produced.

It is evident, therefore, that *Aristolochia elegans* can be self-fertilized. It would also appear that it does not cross with *Aristolochia ridicula.* But observation 4 indicates that even when the flies are compulsorily detained in the flower, self-fertilization does not always occur. The percentage germination of seeds obtained by self-fertilization is in general poor.

SUMMARY.

The flower of *Aristolochia elegans* opens before daybreak. The pollen is liberated during the following night, and the hairs wither at about 8 A.M. on the second morning.

Flies enter the flower throughout the first day, and 128 have been found in a single flower at 5 P.M. They are nearly all the same species, an *Aphiochæta.*

The flies are evidently attracted to the flower by its odour, though it is not perceptible. Some fly into the flower, and others are thrown down the tube by the hairs on the hood.

Food is provided for the imprisoned flies by two definite food areas on the anterior side of the bulb.

The flower may remain rigid until the third day, or it may partly collapse on the second day and become rigid again during the second night.

The gynostegium does not close.

Though flies remain in the flower until the morning of the second day, they can nevertheless escape at any time on the first day, the hinged hairs not being an absolute hindrance in this case.

Isolated plants of *Aristolochia elegans* produce fruits in abundance. The flower can be self-fertilized, though it is probable that cross-fertilization more usually occurs.

Aristolochia gigas Lindl.

The flower of this species is remarkable for its enormous size and its intensely offensive odour.

The flower stalk is sharply defined by its colour from the ovary, and there is a circular leafy bract at the junction of the two (Plate II., fig. 4). The combined stalk and ovary hangs vertically. The bulb (Plate II., fig. 1) is irregularly ovate, narrowed towards the apex, and laterally compressed, up to 12 cm. long, and 6 cm. across the widest part, hexagonal in section (Plate II., fig. 3). It passes below into a tube, which leaves it somewhat obliquely on the lower third of the anterior face, and, after a length of about 3·5 cm., turns vertically upwards. The posterior wall of the tube is continued upwards to about two-thirds the height of the bulb, and expands to form a hood, while the anterior side ascends to less than half that height and then bends outwards to form the lip. Up to this point the structure is similar to that of *A. elegans*, but the remainder of the flower differs in that the margin of the hood already formed bends back sharply to form the large concave limb. The face of *A. gigas* may therefore be regarded as consisting of an outer and an inner hood.

The back of the inner hood is impressed by the wall of the bulb. The anterior wall of the tube is similarly bent inwards to permit the uniform curvature of the limb, and the tube is, in consequence, strongly compressed from front to back just below the mouth (Plate II., fig. 5).

The exterior of the flower is pale greenish-white, or pale yellowish-white, with pale purple-red veining. Six strong veins run, as projecting flanges, down the bulb, and are continued along the tube, united by numerous anastomosing cross veins. The median posterior vein and the next but one on either side are continued as strong ribs on to the lower part of the outer hood, at the base of which they converge and form a long appendage, while the upper parts of the inner and outer hoods are supported by less elevated branches from the two outer of these three. The remaining three veins which alternate with these thin out on the hood and do not reach its margin. The support of the hood is thus furnished chiefly by three veins only.

The wall of the bulb, tube, and inner hood is thick and fleshy. In general, the wall of the bulb is 0·8 mm. thick, but it increases to 3 mm. along the flanges. That of the inner hood is about 0·5 mm. thick, while the outer hood is thin and almost membranous. The six flanges meet at the apex of the bulb and form a socket, in which the ovary is inserted. Just below the apex is a series of depressed, watery-looking areas, one on each sector, though on the two broader lateral sectors they sometimes appear double (Plate II., fig. 2). These areas represent the windows, but on holding the flower up to the light after cutting across the bulb it is seen the whole of the apex of the bulb is translucent.

The face is broadly cordate, up to 30 cm. across, slightly concave, narrowing below into a thin appendage, up to 65 cm. long. In the bud the appendage is triangular, and it sometimes remains in that condition when the flower is open, but in general the dehiscence of the flower continues to the extremity of the appendage, which then forms a flat band, 7 mm. wide, with three strong longitudinal ribs. Round the mouth of the inner hood the face is deep reddish-purple, in a zone which is broadest on the lower side, where it is rough with minute papillæ; elsewhere it is greenish or yellowish-white, streaked with broad, radial, somewhat mottled, reddish-purple bands with anastomosing branches. The inner hood is entirely reddish-purple, and this coloration is continued down the anterior, vertical part of the tube, after which it fades off into white or yellowish-white.

In the basal part the bore of the tube is roughly circular and about 14 mm. in diameter, but in the anterior vertical, compressed part the width is diminished to about 5 mm. Consequently, although large flies do enter the flower, they must find more difficulty in doing so than in *Aristolochia ridicula*. Where the tube enters the bulb, the zone round the opening, which in *A. ridicula* is merely thickened, and in *A. leuconeura* forms a projecting ridge above, is in this species produced into a tube which projects into the bulb for distance of about 6 mm. (Plate II, fig. 5). The diameter of this inner tube varies, but generally it is about one-half that of the tube proper.

The hinged hairs begin just within the margin of the inner hood, and form a dense covering over the whole of the inner surface of the inner hood and the tube. On the purple areas they are violet or purple and up to 2·5 mm. long, but on the white wall of the lower part of the tube they are white and about 1 mm. long. The bore of the tube is consequently unobstructed, except at the constricted part near the mouth, where the hairs almost meet.

The inner wall of the bulb bears small, scattered, glabrous, purple-red spots. Between these it is covered with the usual long hairs, but in this species the hairs are erect and form a velvety pile. In the open flower this pile is somewhat viscid. At the apex the translucent window area is bordered below by a purple-red zone, 1 mm. wide, with a narrower purple line above round the base of the gynostegium. The outer wall of the inwardly-projecting tube is glabrous.

The gynostegium is six-lobed and resembles that of *A. ridicula*. The lobes are bordered by a well-developed fillet, which is thinner at the margin than that of *A. ridicula.*

The young flower is enclosed at first in a boat-shaped bract at the apex of a short stalk. In dry weather many of the flowers do not develop further, but wither when barely large enough to be recognized. If the flower develops the stalk also increases to six or eight times its original length, the bract persisting, more or less circular in form, at the base of the ovary. In the unopened flower the two sides of the face are united vertically by their edges, and form a balloon-like structure.

The flower opens at daybreak. On February 23, the flowers were opening at 6 A.M., sunrise on that date being at 6.26 A.M. In dry weather the gynostegium begins to close in the evening, and at 6 P.M. the fillet has so far recurved that the anthers are clearly visible for their whole length, but in wet weather no change is observable in the gynostegium before dark. The flower loses its offensive odour before sunset on the first day. During the night the gynostegium closes and the pollen is liberated; and shortly after sunrise next morning the hairs wither so that the flies can escape. There is no alteration in the shape of the tube or the mouth. The hood withers about midday on the second day.

Flies are attracted in large numbers, no doubt by the odour, and all sizes from "blue-bottles" to almost midges may be seen flying about the flowers throughout the day. The offensive odour, which resembles that of decaying flesh, is plainly perceptible at a distance of about six yards; and cases have occurred in which the owner has been compelled to cut out a plant, which has been planted too near a bungalow, because of its smell. The smell arises from the deep purple inner hood, not from the bulb, tube, or outer hood, and it is not perceptible when the unexpanded flower is prematurely opened.

The flies alight on the face, and walk into the flower over the lip at the lower edge of the tube, or over the margin of the inner hood. In the latter case they disappear into the concavity behind the margin, and, a few moments later, one often sees them precipitated downwards into the tube. The same often happens when they alight on the back of the inner hood; after walking about for a brief while, they are shot down into the tube. Some may struggle out again. This exactly resembles the action in *Aristolochia elegans*, and in both these flowers it would appear that the fly is catapulted downwards by the recoil of the hairs it has displaced. I have not, however, been able to observe that the hairs have any active response to a stimulus.

If the side of the bulb is cut open at any time on the first day, all the living flies immediately escape. None remain behind feeding in the bulb. Some have been observed to re-enter the flower *viâ* the mouth, and to escape again as soon as they reached the bulb. None have been seen to enter the bulb *viâ* the opening, although the whole of one panel may have been cut away. In these respects, *Aristolochia gigas* differs from *A. ridicula* and *A. elegans*, as in both the latter species, flies will enter the bulb directly, and will remain feeding in the bulb after it has been cut open. It would appear that *A gigas* does not provide any food within the bulb for the flies.

A flower gathered on the day of opening at 4.45 P.M., and placed in a cyanide bottle immediately, contained 164 flies; the morning had been dull and showery, but the afternoon fine.

A similar flower, gathered on another date at 6 P.M., contained 203 flies; there had been heavy rain for the greater part of the afternoon.

Two similar flowers, gathered on a third occasion at 5 P.M., contained 87 and 153 flies respectively.

Three similar flowers, out of six which had opened that day, were gathered at 4.45 P.M.; they yielded 150, 198, and 199 flies.

On a fifth date the only flower opened, when gathered at 5 P.M., contained 57 flies.

The flies lay numbers of eggs or larvæ on the inner hood and within the bulb and the tube.

Random observations showed that some flies were still in the flower after 8 A.M. on the second morning. A flower gathered at 8.45 on the second morning contained some living flies, but the greater number were either dead or stupified, and were lying both at the base of the bulb and within the tube. Another flower gathered at 8.45 on the second morning was found to contain sixty-six dead flies only. A third flower was gathered at 8.15 on the second morning, the mouth plugged with cotton wool, and conveyed to the laboratory where it was placed under a bell glass and the plug removed; one small fly escaped immediately, but no others emerged up to 3 P.M., when the flower was opened and found to contain one living fly and two hundred and seventy-three dead. To obtain further information on this point the following experiments were carried out.

On February 24 a flower was enclosed in a large muslin bag at 7 A.M. on the second day. The hairs had then withered, but the flies had not all escaped. When examined at 2 P.M. twenty-one dead flies were found in the flower, while in the bag outside the flower there were six flies alive and twenty-one dead. Thus, of twenty-seven flies which had emerged after 7 A.M., twenty-one died while enclosed with the flower in the bag.

Another flower was bagged at 6 P.M. on the day of opening (February 25). At 8 A.M. the next morning a number of flies had emerged, one of which was already dead. At 12 noon many were still alive, but at 2 P.M. all were dead with the exception of one "blue-bottle." In the flower there were then twenty-one flies dead, one fly alive but stupefied, and a staphylinid beetle alive and active; in the bag there were sixty-seven flies, all dead but one.

Very many of the flies in the bag survived until after midday. The plant on which the flowers were growing was in the shade until 12.30 P.M., and it was thought possible that the subsequent exposure to full sunlight might have some effect on the imprisoned flies. The last experiment was therefore varied by cutting off the flower at 12 noon, and putting the bag, with the flower still in it, in the shade until 2 P.M. There were then in the flower twelve dead flies and one living, and in the bag fifty-eight dead flies and eleven living.

In a repetition of the last experiment, 82 dead flies and one living were found in the bag at 2 P.M., while one living fly and over 72 dead were found in the flower. The exact number which had remained in the flower could not be ascertained, as many had been devoured by larvæ, which in this instance were present in greater number than usual.

At the time these experiments were carried out, only one flower was open on each day, and as the flies in each flower were killed there was no possibility that those which died during the experiment had previously been imprisoned in another flower.

Other observations have shown that even on the first day, at 4.30 P.M., many of the flies in the flower may be either dead or stupefied. It is clear that many of the flies die within the flower. Some die before the hairs have withered, but others fail to escape on the second morning and die later.

The circumstances attending the liberation of the flies present several peculiarities. In some cases all the living flies have escaped before 7 A.M., *i.e.*, soon after the hairs have withered, but in general they emerge, not all at the same time, but promiscuously up to 8 A.M., or even later. As a rule, the larger flies manage to escape, but I have observed cases in which nearly all the flies dead within the flower were large "blue bottles." The killing is not selective; the flies found dead within the flower are of the same species as those which escape.

There is no evident structural feature which might hinder the emergence of the flies; indeed, even before the hairs wither the bore of the tube is practically unobstructed until the narrow mouth is reached, as the internal diameter of the tube is about 14 mm. and the hairs are only about 1 mm. long. The backward prolongation of the tube into the bulb does not offer any obstacle, for if the tube is cut across at its lowest point at any time on the first day, all the living flies escape. Moreover, the occurrence of dead flies in the tube shows that they are not prevented from leaving the bulb.

The anterior vertical part of the tube is directed slightly backwards, and opens under the dark, purple, inner hood (Plate II., fig. 5). The opening is thereby darkened, and it may possibly be darkened to such a degree that the flies are not specially attracted in that direction. Nevertheless, in general, the majority of the flies do not find that an obstacle.

It would seem probable that the flies which are alive when the hairs wither, but do not escape, are too dazed to do so.

The occurrence of dead flies within the flower, even before the close of the first day, suggested that the flower produces some substance which kills them; and the fact that the flies which have escaped die if imprisoned in a muslin bag with the fading flower was thought to offer some support to that suggestion. The following experiment was therefore carried out:—At 5.30 P.M. a flower was enclosed in a muslin bag, the outer face being cut off for convenience of handling. At 8 next morning the flower was removed from the bag, and the latter, containing the flies which had escaped from the flower, was hung up on the plant. No other flowers were open. In the flower there were then 52 dead flies and 16 alive but dazed, the latter including 9 *Lucilia* and 1 *Sarcophaga*. In the bag there were 39 flies (as counted later), all alive. At 1 P.M. only three small flies remained alive in the bag, and these died shortly afterwards. Consequently, the death of the flies after they had escaped from the flower in the previous experiments was not due to the presence of the dying flowers.

In the other species of *Aristolochia* dead flies are rarely found in the flower under normal conditions. In *Aristolochia ridicula* two-thirds of the flies survived an imprisonment of up to forty-eight hours, although the entrance of the flower was blocked with cotton wool for half that period. It is, however, to be noted that the majority of the flies which died in the latter case were the largest species which frequents the flower.

In the case of *Aristolochia gigas* the occurrence of dead flies in the flower is normal, and in some cases they are so numerous that the casual observer gains the impression that all the flies which enter the flower die. Indeed, the average visitor to Peradeniya who sees the dead flies in the flower goes away with the idea that *Aristolochia gigas* is a carnivorous plant. The data of the foregoing experiments, however, show that, in one case, 67 out of 89 flies emerged; in another, 69 out of 82; in a third instance, 83 out of more than 156; and in a fourth, 39 out of 107.

The number of flies in a flower of *Aristolochia gigas* is usually very large, and it may be that the death of the flies on the first day is due to suffocation through overcrowding. That however, cannot account for the death of the flies which have escaped, when imprisoned in a muslin bag. It may be noted that Speyer recorded (Annals of Applied Biology, VII., p. 128), that in his experiments on the chemotropism of the house-fly, there was a high percentage of mortality among the flies after they had entered the traps.

In a collection of 1,325 flies from the flowers of *Aristolochia gigas*, 17 species were found. Six species were represented by single examples, and another species by three. The *Sarcophaga* which is found in *Aristolochia ridicula* was present to the number of 155. Other species were *Chrysomyia* ? *combrea* Walk. (69), *Chrysomyia dux* Esch. (52), *Chrysomyia megalocephala* Fb., *Lucilia* sp. (51), *Lonchæa* sp. (10), and *Ophyra* spp. (81). Three unidentified species were present in the numbers 794, 77, and 27 respectively; these three are *Anthomyidæ.*

Hart collected flies from *Aristolochia gigas* var. *Sturtevantii* in Trinidad, which were determined by Mr. E. E. Austen. The species found were *Lucilia*, 2 species; *Compsomyia macellaria* F; *Musca domestica* L.; *Sarcophaga* sp.; *Ophyra ænescens* Wied.; and a Tachinid (Bulletin of Miscellaneous information, Royal Botanic Gardens, Trinidad, III. (1897), p. 29).

Isolated plants of *Aristolochia gigas* do not bear fruit in Ceylon, but if several plants are grown together they fruit fairly abundantly. In the Botanic Gardens, Peradeniya, it has been customary to grow a single plant in the flower garden, and no fruits were ever produced. In 1919, however, two plants were grown on the same trellis and came into bloom at the same time, with the result that several fruits were formed, in spite of the fact that the majority of the flowers were mutilated on the day they opened, or before they opened, by visitors.

Several attempts to fertilize the flowers with pollen from the same plant proved failures. It would appear, therefore, that *Aristolochia gigas* is self-sterile. No success has attended attempts to fertilize the flowers of a plant at my bungalow with pollen from a plant in the Botanic Gardens; this has been tried on five occasions, with twelve flowers in all. Transfer of flies from one flower to another has not yet been attempted.

SUMMARY.

The flower of *Aristolochia gigas* opens at daybreak, and the stigmatic area is then receptive. In dry weather the gynostegium begins to close in the late afternoon, but in wet weather this does not take place until after dark. The gynostegium closes during the night, and the pollen is liberated.

Flies enter the flower during the first day, being attracted by its strongly offensive odour which emanates from the deep purple, inner hood. They appear to be shot into the tube by the recoil of the hinged hairs on that area. The flower loses its odour towards evening on the first day.

The hinged hairs in the tube wither shortly after sunrise on the second morning, the full series of changes in the flower occupying little more than twenty-four hours. The flies emerge between 6 and 8 A.M.

Large numbers of flies enter the flowers, up to 274 having been found in a single flower. The species include *Sarcophaga*, *Lucilia*, *Chrysomyia* ? *combrea* Walk., *Chrysomyia dux*, *Lonchæa*, and *Ophyra*, but the chief visitor is an unidentified Anthomyid.

Very many of the flies which enter the flower die in it. Some die on the first day, while others fail to escape on the second day and die then. The reason of this has not been ascertained.

Aristolochia gigas does not appear to provide any food for the imprisoned flies.

Isolated plants of *Aristolochia gigas* do not bear fruits, but if two plants are grown together, fruits are produced. Hence it is probable that *Aristolochia gigas* is self-sterile.

Aristolochia leuconeura Linden.

The flowers of this species are borne in clusters on the old stems, often near the ground.

The bulb is attached laterally to the ovary, either perpendicularly or slightly obliquely (Plate II., fig. 8). It is oval, about 1·75 cm. long and 1 cm. diameter, passing below into the tube, which bends forward horizontally or obliquely, with a slight groove or wrinkle on the upper side where it leaves the bulb, and expands into the funnel-shaped face. The whole of the exterior of the flower—ovary, bulb, and tube—is usually purple-brown or vinous. Sometimes, however, the bulb is green, netted with vinous veins. The apparent stalk is ribbed nearly to the base, being almost entirely the ovary. In Curtis's Bot. Mag., Plate 5 420, the ovary is depicted as green.

As the flowers are grouped in dense clusters, the rigid stalks may interfere with one another and consequently the presentation of the flower is not always constant. This is especially the case when the flower clusters arise at ground level. Where the flower has room to take up its proper position, the stalk (ovary) bends downwards from the point of attachment, and after a short distance turns almost at right angles into a position at a small angle above the horizontal. This throws the bulb obliquely forwards, so that the tube is horizontal with the funnel curving upwards, and the limb directed backwards horizontally over the bulb (Plate II., fig. 8). On the second day the anterior part of the ovary curves downwards, and throws the bulb obliquely backwards; the tube, in consequence, is directed downwards, and the mouth of the funnel is vertical. At the same time the flat portion of the face loses its backward curvature and becomes vertical also (Plate III., fig. 1).

The tube is about 4 mm. in diameter externally, with a bore of about 2·5 mm. It expands into a laterally-compressed funnel-shaped mouth. The face is oval (Plate III., fig. 2), narrowed towards the base, about 4 cm. high, and 2 cm. broad; it is merely a continuation of the funnel, the upper margin being produced into a flattened, recurved limb, which terminates above in a short, thin appendage, and is bilobed at its lowest point. Within the funnel (Plate III., fig. 3), the face is yellow, with liver-brown radial streaks; the flatter limb above is mottled, yellow and liver-brown, the yellow areas being slightly-elevated tubercles.

The hinged hairs begin about the middle of the striped area and are continued down the tube. On the striped area they are brown, or white with brown tips, or white; on the yellowish inner wall of the tube they are white. In the lower part of the tube they almost meet in the centre.

The apex of the bulb is translucent, and forms a window area, but this is not marked off by a coloured zone. Owing to the thickness of the fleshy wall, the window area is not evident from the exterior, but it is clearly visible from the interior when the bulb is cut open and held up to the light. As usual, the wall is thicker over the window area, being about 1 mm. thick there, as against 0·6 mm. over the remainder of the wall of the bulb. The window area bears a few erect, rigid, scattered hairs; elsewhere the wall is yellowish-white and clothed with the usual long, woolly hairs.

Above the inner end of the tube a triangular ledge (Plate II., fig. 9) extends horizontally into the bulb. This ledge is about 5 mm. broad in the middle, and thins off and curves downwards on either side, forming a hood over the entrance to the tube. The lower surface of this ledge is smooth, and in continuation of it a narrow smooth zone extends round the lower side of the opening. Its upper surface is also smooth, except for a minutely tomentose patch at each corner. The wall of the bulb forms a pouch on the upper side of the ledge. Above the ledge is a transverse yellowish patch which apparently is the food area, but it is not well defined, and the hairs on it do not differ from those on the other parts of the wall.

The whole of the wall of the flower, even the limb, is thick and fleshy, and glabrous externally.

The gynostegium is normally six-lobed, but examples with five lobes are not uncommon, and one case of seven lobes has been found. Two of the lobes in the latter were not completely separated, but the seven anthers were perfect. It is of the same type as that of *A. ridicula*, but is more deeply divided, and the teeth are, relatively to its size, longer and more attenuated (Plate III., fig. 4). At first the margins of the teeth are recurved and form a fillet which projects to the same level as the anthers. This curvature of the edge, however, does not extend to the apex. On the second day the flower is open, the fillet curves back, so that the outer faces of the teeth become plane, and the attenuated apices of the teeth curve downwards into the cavity of the gynostegium, but at the time the pollen is liberated the teeth have not met in the centre and there are wide spaces between them laterally (Plate III., fig. 5). The closure is not complete until several hours later. The upper surface of the gynostegium is more viscid than that of *A. ridicula*, and small flies are sometimes firmly held by it. If caught by a wing, or sometimes by a single leg, they are unable to escape, and are usually wedged between two of the teeth as the gynostegium closes.

The flowers open later than those of *A. ridicula*, at about 9 A.M., or between 8.30 and 9.30 A.M. The full process of expansion is somewhat prolonged, and the face remains entirely funnel-shaped for about an hour, but by about 10.30 A.M. the upper part has become flat. At 9 A.M. on the following day the curvature of the ovary, already referred to, has been completed in the majority of the flowers, and the face in these is vertical, though some may still be horizontal. The hairs begin to wither at the inner end of the tube at about 10 A.M., but this condition does not extend to the hairs in the mouth of the funnel until after 11 A.M. At the latter hour, the flies are still imprisoned, but by 11.30 A.M. all the hairs have withered and the flies have escaped. The above observations were made in June, during showery weather.

At 9 A.M. the anthers in the day-old flowers are not open, but a quarter of an hour later the pollen is liberated. The gynostegium is not then completely closed; its teeth have curved over, but have not met in the centre, and there are gaps between them at the sides. The flies found in the bulb between 9.15 A.M. and 11 A.M. are usually covered with pollen, many of them bearing yellow masses of it on the thorax.

The course of events in *A. leuconeura* is thus similar to that in *A. ridicula*. The full sequence occupies about twenty-six hours, and the anthers dehisce and the insects are liberated on the second day after the opening of a fresh series of flowers. It differs from *A. ridicula* in that the closure of the gynostegium is less complete at the time the anthers dehisce.

The flower has a slight odour of stale meat, not strong enough to be offensive. It appears to emanate solely from the tubercular area of the limb. *Sarcophaga* sp. and other large or medium-sized flies are attracted to the flower and alight on the face, though they cannot possibly enter as the tube is too narrow to permit their passage. The flies found in the bulb are all small.

During May, 1915, all the flowers which opened were collected almost daily at about 5 P.M. from an isolated plant for sixteen days. From sixty-three flowers 295 flies were obtained, an average of 4·7. The greatest number found in a single flower was 20, but in only seven cases did the number exceed 9. Seven flowers of the sixty-three did not contain any. The weather throughout was fine.

In a collection of 255 flies, thirteen species were present. 123 were *Aphiochæta* spp. Two other species, unidentified, were present to the number of 61 and 51 respectively. *Lonchæa* sp., *Discomyza* sp., and *Hippelates* sp. were represented by two examples each. The remainder included one species, five examples; one species, three examples; two species, two examples each; and two species, one example each.

Isolated plants of *Aristolochia leuconeura* fruit sparingly at Peradeniya. Relatively to the size of the flower the capsule is enormous, attaining a length of 16 cm. and a diameter of 1·5 cms. Seeds planted on June 6, 1918, germinated on November 22, 1918.

SUMMARY.

The flower of *Aristolochia leuconeura* opens at about 9 A.M. Flies are attracted to the flower by a faint odour, resembling that of stale meat, which emanates from the tubercular area of the face. Large flies, *e.g.*, *Sarcophaga* sp., which cannot enter the flower, are attracted.

On the first day the funnel-shaped face is directed upwards, but on the second morning, owing to changes in the curvature of the ovary, it becomes vertical.

The pollen is liberated shortly after 9 A.M. on the second day. The gynostegium is then not completely closed. The hairs in the tubes wither about 11 A.M.; and the imprisoned flies escape soon afterwards.

The full series of changes in the flower occupies about twenty-six hours.

The principal visitor to the flowers at Peradeniya in an *Aphiochæta*, but thirteen species have been taken from them.

Isolated plants fruit sparingly at Peradeniya. It is probable that cross-fertilization is the normal method, but no experiments have been made on this point.

Aristolochia floribunda Lem.

Despite its name, this species runs chiefly to leaf at Peradeniya, flowering only sparsely even in the case of an old-established plant.

In the bud the unexpanded limb is flattened and somewhat triangular, the two halves of the face being closely applied to one another. Dehiscence occurs along the outer edge, and for a short distance along the upper and lower edge, and the two halves curve strongly backwards, the final form of the face being funnel-shaped with a strong recurved margin, bilobed above and below (Plate III., fig. 7). The flower hangs with the opening of the funnel directed upwards, from an angle of 45° to almost vertical.

The open face is vertically oval, up to 8 cm. long and 5 cm. broad (Plate III., fig. 6). Its colour is red-purple, with darker, radial, broken streaks. The area round the mouth is bright orange-yellow. Hinged hairs ascend to the edge of the lower side of the funnel, but are absent from the orange-yellow area. At first the face is viscid, and flies may be observed feeding on the sticky substance which covers it.

The tube is about 1·3 cm. long, laterally compressed, about 4 × 3 mm. externally and 3 × 2 mm. internally, expanding above into the funnel-shaped mouth. It is sparsely lined with short, hinged hairs, which are white, mottled with purple (Plate III., fig. 8).

The tube and bulb are pale greenish-white. The latter is irregularly oval, 2 cm. long, 1·2 cm. diameter, with its wall deeply invaginated above the tube. Internally the invaginated region forms a smooth, yellow, thickened zone above the tube opening and down each side, thinning off into a smooth, unthickened, yellow zone round the lower side; the upper part of this forms a horizontal ledge, 3 mm. broad, notched in the middle (Plate III., fig. 9).

The interior of the bulb is greenish, or yellowish-white, and is lined with woolly hairs. There is a definite window area at the apex, demarcated by a mottled purple zone. Septate hairs, not hinged, occur on the window area. A somewhat indefinite, moist food zone, interrupted in the middle, is situated just above the thickened region over the opening of the tube (Plate III., fig. 9).

The apex of the ovary is curved downwards and socketed into the bulb, so that the bulb appears to be lateral. The anterior margin of the socket is more elevated than the posterior.

The gynostegium is six-lobed. The edges of the lobes are slightly reddish, and this coloration becomes more pronounced on the second day.

The flower opens before sunrise. On September 20 it was fully expanded at 6 A.M., sunrise on that date being at 6.1 A.M. The fillet round the lobes of the gynostegium curves back during the first night, and the pollen is liberated, but there is practically no change in the position of the teeth. The hairs in the tube wither about 8 A.M. on the second day. The flower has a faint odour, which resembles that of *A. leuconeura.*

Of thirteen flowers gathered at about 5 P.M. on the first day on different dates extending over a period of two months in 1919, six did not contain any flies. The other seven together contained only eleven flies, one containing five, and the others one each. It is noteworthy that, of the eleven flies, six were *Acidia fossata* F., *Trypetidæ.* In three cases the flies were drowned in the flower.

Relatively to the number of flowers, isolated plants of this species at Peradeniya fruit rather freely.

Further observations were made at Peradeniya in 1921 on two plants of this species, one in the Botanic Gardens and other in my bungalow garden. In that year the plants flowered more abundantly.

From the plant in the Botanic Gardens flowers were gathered at about 4 P.M. on their first day over a period of two months. Of 191 flowers, 109 did not contain any flies. The remainder contained 156 flies, of which 91 were *Acidia fossata.* The greatest number of flies in a flower was 15, and the average number per flower 0·82. 57 per cent. of the flowers did not contain any flies, and 58 per cent. of the flies caught were *Acidia fossata.*

From the bungalow plant 68 flowers were gathered, and of these, 20, or 29 per cent., did not contain any flies. The remainder contained 127 flies, of which 123, or 97 per cent. were *Acidia fossata.* The average number of flies per flower was 1·87.

Combining all the records, we find that 272 flowers contained 294 flies, or an average of 1·1 flies per flower. 135 flowers, or 50 per cent., did not contain any. 220 of the flies, or 74·8 per cent., were *Acidia fossata.* The remaining flies included *Sciara* sp., *Ceratopogon* sp., *Aphiochæta* spp., *Chlorops* sp., *Hippelates* sp., *Meromyza* sp., *Drosophila* sp. (2 examples), and *Scatopse brunnescens* (Brun.). A small brown ant occurs commonly in this flower.

The following records show the variation in the number of flies on consecutive days :—

July 4, 1921 : Three flowers : 2 *Acidia fossata* : weather fine.
,, 5, 1921 : Ten flowers : 3 *Acidia fossata,* 3 others : showers.
,, 6, 1921 : Four flowers : 1 *Acidia fossata* : fine.
,, 7, 1921 : Thirteen flowers : 5 *Acidia fossata* : showers.
,, 8, 1921 : Five flowers : 7 *Acidia fossata* : showers.
,, 9, 1921 : Six flowers : 2 others : fine.
,, 10, 1921 : Eight flowers : 17 *Acidia fossata,* 5 others : dull.
,, 11, 1921 : Seven flowers : 3 *Acidia fossata,* 22 others : fine.
,, 12, 1921 : Ten flowers : 4 *Acidia fossata* : fine.

It is not possible to trace in the records any definite relation between the number of flies per flower and the weather. Nor is the plant more attractive, the more flowers there are open at one time. Nor is the average number of flies per flower greater as the number of flowers decreases.

SUMMARY.

The flower of *Aristolochia floribunda* opens before sunrise. The pollen is liberated during the following night, and the hairs wither at about 8 A.M. on the second day.

Flies are attracted to the flower by its odour, and feed upon a viscid substance which covers the face.

Fifteen flies have been found in a single flower, but 272 flowers collected at 4 P.M. on their first day on different occasions contained only 294 flies, or an average of 1·1 flies per flower. Fifty per cent. of the flowers did not contain any flies.

The principal visitor to *Aristolochia floribunda* at Peradeniya is a Trypetid, *Acidia fossata*, this forming nearly seventy-five per cent. of the total.

The gynostegium is not closed at the time the pollen is liberated.

The flower contains food areas within the bulb.

Isolated plants of *Aristolochia floribunda* fruit rather freely, considering the small number of flowers produced.

Aristolochia indica L.

The flower of this species differs from that of most of the foreign species, cultivated in Ceylon, in having a distinct pedicel, about 4 mm. long and 1 mm. diameter, between the ovary and the bulb.

The bulb is pale glaucous green, subglobose, or somewhat pyriform and produced in front, about 6 mm. diameter, divided into six sectors by longitudinal grooves (Plate I., fig. 10). On each of the two upper sectors, towards the anterior end, is a small hemispherical swelling. In the normal position of the flower the bulb is directed slightly obliquely downwards.

The bulb passes over directly into the tube. In the young bud the flower is straight; but the tube subsequently turns up into a vertical position. The tube is about 2 mm. diameter below, and more or less cylindric, but expands and becomes compressed above and terminates in a horizontal funnel-shaped mouth, about 6 mm. from side to side and half that distance from front to back. The total length of the tube is about 1·2 cm. The anterior edge of the mouth bears a median V-shaped groove; the posterior side is produced into an oval limb or standard, pointed above, about 1·5 cm. high and 1 cm. broad. The edge of the funnel and the margins of the limb are strongly recurved.

The rim of the mouth is purplish, and bears a fringe of purple hinged hairs. The limb is deep purple below and livid brown above, the purple area bearing purple, hinged hairs, like those on the rim of the funnel. It is grooved down the middle, along the line of folding in the bud. In the unexpanded flower the two halves of the limb are closely applied to one another and united by their anterior edges, while the rim of the mouth is infolded and united along the median line.

Externally the tube is pale glaucous green, like the bulb, and both bulb and tube are smooth. The wall is rigid and rather fleshy, resembling that of *Aristolochia elegans*; consequently the window area is not visible externally.

The base of the limb and the interior of the tube on the posterior side are pale green, but on the anterior side a triangular purplish area extends downwards and is continued in the tube as a narrow vertical band. About half way down the tube the wall becomes uniformly purple all round, but the colour changes to pale green again a short distance before the junction with the bulb. The whole of the interior of the tube (Plate I., fig. 11) bears short, purple, hinged hairs not more than 0·4 mm. long. These are rather sparsely scattered, but are denser on the purple area. They have laterally expanded bases, like the hinged hairs of *A. ridicula*, but are slightly constricted at the septa. The hairs on the limb have rounded bases.

The bulb is reddish-purple internally, except for a clear apical window area round the gynostegium. This area is traversed by six narrow lines of erect hairs, usually purple, and is bordered by a fringe of similar erect hairs. These hairs are not hinged. The six lines correspond in position with the external grooves, and they may be continued as darker lines across the purple inner wall of the bulb. The general interior surface of the bulb is, as usual, woolly hairy.

Round the inner opening of the tube (Plate I., fig. 13) the wall is pale green and glabrous. Above this are two depressed purple-black, pyriform spots, which correspond with the swellings noted from the exterior. Each is situated in an oblong, oblique, white area which is rounded above, the two areas fusing below, but leaving a V-shaped purple area between them above. This white area is finely tomentose, and corresponds with the food areas of *A. elegans.*

The gynostegium (Plate I., fig. 14) is six-lobed. The lobes are triangular-pyramidal, with the outer face convex, seated radially on a disc; the edge of which is curved downwards and closely applied to the connective column which bears the anthers. When the flower first opens, this curved edge covers the upper ends of the anthers, and the fringe of erect hairs at the edge of the window area assists in keeping away from the anthers the insects which enter the flower. On the second day, however, the disc margin shrinks and curls up (Plate I., fig. 15), first in six rounded lobes, and afterwards in a continuous ridge, so that the six teeth of the gynostegium appear immersed in a shallow cup. The teeth then curve inwards, so that their inner edges become more or less vertical.

The flower opens shortly before sunrise. On December 1 (sunrise 6.8 A.M.), the flowers were in course of opening at 6 A.M. Dehiscence occurs first along the edge of the folded limb or standard, and extends downwards over the entrance of the tube. The edges of the mouth of the tube next become recurved, and finally the edges of the limb curl back. The full process of expansion is somewhat prolonged, and the edges of the limb may not be fully recurved before 8 A.M., or later. The flower has no appreciable smell.

The flower retains its erect position during the first day. During the night the edges of the gynostegial disc curve upwards and the anthers open. The hairs bordering the window area do not wither. The combined stalk, ovary, &c., up to the bulb, which at first is doubly curved, now assumes a single continuous curve directed downwards. The tube bends over at a greater angle with the bulb, and the limb bends forward over the mouth of the tube, but not near enough to close it (Plate I., fig. 12). As a result of these changes the tube becomes horizontal or directed obliquely downwards, while the limb points almost vertically downwards and hides the entrance of the flower.

The hairs in the tube wither between 8.30 and 10 A.M. on the second day. Those at the margin of the tube, however, do not wither until much later, and they may be still rigid at 11 A.M., but as they are comparatively short and directed outwards, it is probable that they do not impede the exit of insects, especially as the tube is directed downwards on the second day.

The plant under observation at Peradeniya flowered abundantly, but insect visitors were relatively few, and only a few fruits were produced when the flowers were left undisturbed. The following observations have been recorded. Except in the case of the flowers gathered at 4.30 P.M., the flies were allowed to escape in the neighbourhood of the plant after examination.

Of seven flowers gathered at 8.30 A.M. on the day of opening, one contained one fly. On another occasion of two similar flowers gathered at the same time, one contained one fly.

Of sixteen flowers gathered at 12 noon on the day of opening, three contained one fly each.

Flowers were gathered at 4.30 P.M. on the day of opening on the following dates :—

1918, May 3 : 6 flowers ; one fly in one.
,, 4 : 5 flowers ; no flies.
,, 20 : 6 flowers ; five flies in one ; very wet day.
,, 23 : 3 flowers ; one thrips in one ; very wet day.
,, 24 : 3 flowers ; no flies.
,, 30 : 11 flowers ; no flies.
,, 31 : 5 flowers ; no flies.
June 1 : 8 flowers ; no flies.
,, 5 : 8 flowers ; three without flies ; 1, 1, 3, 4, 14 in the other five, respectively.
,, 6 : 11 flowers ; one fly in one.
,, 7 : 7 flowers ; no flies.
,, 8 : 9 flowers ; no flies.
,, 9 : 8 flowers ; one fly in one.

Thus, ninety flowers gathered at 4.30 P.M. yielded only thirty-one flies, and of these fourteen were obtained from a single flower. Only nine flowers contained any flies.

Owing to the small number of flies which visited the flowers of this particular plant, it was not possible to determine very accurately at what time they were permitted to escape on the second day.

Flowers a day old were gathered at intervals on the same day, and examined with the following results :—

8.30 A.M. : Anthers dehisced ; hairs in tube not withered ; one fly.
9 A.M : Anthers dehisced ; hairs in tube not withered ; no flies.
9.15 A.M. : Anthers dehisced ; hairs in tube not withered ; no flies.
9.30 A.M. : Anthers dehisced ; hairs in tube not withered ; no flies.
10.15 A.M. : Anthers dehisced ; hairs in tube withered, marginal hairs rigid ; no flies.

Other flowers in the same stage of development were gathered at the following times and dates, all the flowers a day old being taken on each occasion :—

June 20, 9 A.M. : 13 flowers ; one fly in one.
,, 21, 9.30 A.M. : 13 flowers ; no flies.
,, 22, 9.30 A.M. : 18 flowers ; three flies in one.
,, 23, 9.30 A.M. : 22 flowers ; one fly in each of two.
,, 24, 10.20 A.M. : 14 flowers ; four with 2, 1, 1, 1 flies, respectively.
,, 26, 10.30 A.M. : 28 flowers ; two with one fly each.
,, 27, 11 A.M. : 18 flowers ; three with one fly each.
,, 28, 11 A.M. : 10 flowers ; two with one fly each.

July 2, 11 A.M. : 16 flowers ; no flies.
,, 3, 11 A.M. : 10 flowers ; two flies in one ; marginal hairs generally not withered.
,, 4, 11 A.M. : 11 flowers ; one fly in one ; marginal hairs generally withered.
,, 5, 11 A.M. : 6 flowers ; no flies ; marginal hairs withered in one flower only.
,, 6, 11 A.M. : 11 flowers ; no flies ; marginal hairs not withered.
,, 7, 11 A.M. : 7 flowers ; no flies.
,, 8, 11.15 A.M. : 3 flowers ; no flies.

Of the flowers gathered at 9.30 A.M., 3 out of 53, or 5·7 per cent., contained flies; of those gathered about 10.30 A.M., 6 out of 42, or 14·3 per cent., contained flies ; and of those gathered at 11 A.M., 7 out of 89, or 7·9 per cent., contained flies. The percentage of flowers which contained flies when gathered at 4.30 P.M. on the day of opening was ten per cent. Obviously the numbers are too small to afford any definite conclusion, and all that can be deduced is that the flies are, in some cases at least, not liberated until after 11 A.M. It is not evident why this should be the case, seeing that the hairs in the tube wither earlier.

Of 400 flowers gathered at 12 noon on their second day, only four contained any flies ; on three occasions one flower contained a fly, and on another one flower contained two flies. These flowers were gathered from two plants in different localities during a period of four months (December-April), on 44 occasions.

Examinations for pollen on the stigma of the flower on the day of opening were made as follows :—

Seven flowers of the previous day were gathered at 10.40 A.M. ; they had shed their pollen and did not contain any flies. Nine flowers which had opened that morning were gathered at the same time ; only one of them contained a fly, and there was no pollen on the fly or the stigma.

On another occasion 10 flowers of the previous day were gathered at 10.30 A.M., and were found to have shed their pollen and not to contain any flies. Seventeen flowers which had opened that morning were gathered at the same time, but they did not contain any flies.

On a third date 13 flowers of the previous day were gathered at 10.40 A.M.; the pollen had been liberated and there were no flies in the flowers. Eighteen flowers which had opened that morning were gathered at the same time, and three of these contained 1, 1, 2 flies, respectively, but no pollen could be detected on the flies or the stigmas.

With the exception of a single thrips, which no doubt entered the flower by accident, all the insects found in the flowers of *Aristolochia indica* are of the same species. This is in striking contrast to the conditions which prevail in the case of the majority of the foreign species of *Aristolochia* which have been introduced into Ceylon. Most of these attract a miscellaneous collection of insects, but the native *Aristolochia indica* is apparently adapted to a single species. The paucity of flies in the flowers of the plant under observation at Peradeniya is probably to be explained by this, for obviously the number which visit the flowers is limited by the number of individuals of that particular species in the immediate neighbourhood, and the presence or absence of flies in the flower may depend upon the phases of the life-history of the fly. One cannot assume, when flies are not found in the flower at a given time on the second day, that they have been liberated. For example, after the plant had been allowed to bloom undisturbed for several weeks, thirty-nine flowers of the previous day were gathered at 9.30 A.M. and were found untenanted; at 4.30 P.M. on the same day all the flowers which had opened that morning, thirty-five in number, were gathered and examined, but only one fly was found. Consequently, it is probable that no flies had been present in the flowers of the previous day.

The fly which visits *A. indica* has not yet been identified, but it belongs to the *Chironomidæ*.

Seeds planted on December 22 germinated on January 20.

SUMMARY.

The flower of *Aristolochia indica* opens shortly before sunrise. During the first day the tube and limb are erect, and the anthers are partly covered by the decurved edge of the disc which bears the teeth of the gynostegium.

During the night the edge of the gynostegial disc curves upwards, and the anthers open. Owing to changes in the curvature of the ovary the tube becomes horizontal, or is directed obliquely downwards, while the limb points almost vertically downwards.

The hairs in the tube wither between 8.30 and 10 A.M. on the second day, but those at the margin of the tube may remain rigid until 11 A.M.

In some cases the flies do not escape until after 11 A.M.

Aristolochia indica has well-defined food areas within the bulb.

Only one species of fly has been observed in the flowers of *Aristolochia indica* at Peradeniya.

Isolated plants at Peradeniya produced fruit sparingly. This may have been due to the scarcity of the particular fly which visits the flowers.

Aristolochia bracteata Retz.

This, the other native Ceylon species, does not grow at Peradeniya, but is found along the coast. It is a low straggling plant, not a climber, and often grows in fairly large masses. Its flower is similar in structure to that of *A. indica*, but the limb, in the bud, is folded into a triangular tube, and, when expanded, its face is covered with hinged hairs up to the apex.

Chance observations made on this species at Batticaloa in December showed that at 9.30 A.M., of nineteen flowers of the previous day, fifteen did not contain any flies, while the remainder contained 4, 1, 1, 1, respectively. At the same time, of thirteen flowers which had opened that day, five were untenanted, four contained one fly each, two contained two flies each, while the others contained four and five flies, respectively. The plants were fruiting abundantly.

The flies in *A. bracteata* were all the same species, and apparently identical with that found in *A. indica*.

Aristolochia ringens Vahl.

An *Aristolochia* under the name of *A. ringens* has been cultivated at Peradeniya since before 1880. It differs in several respects from the species figured on Plate 5,700 of Curtis's Botanical Magazine, the flower being darker, the beak not so widely open, and the narrower part of the standard being hairy. The description in the Botanical Magazine states that the beak is hairy inside below the middle, but in the species cultivated in Ceylon it is hairy up to the edge.

In the young bud the flower is, as usual, straight, the bulb and the ovary being in the same straight line. It then bends over, so that the bulb becomes almost parallel to the ovary, and the latter curves downwards so that the unexpanded flower lies within the curve (Plate IV., fig. 4). Subsequently a reverse curvature of the ovary brings the flower to its final position.

The ovary is purple and strongly ribbed, and curves over abruptly at right angles at the apex, so that the bulb appears to be attached laterally (Plate IV., fig. 1).

The apex of the bulb is expanded into a disc, obconic below and flat on the upper surface, hexagonal, with six, slightly projecting teeth. The apex of the ovary is inserted slightly to one side of the centre of this disc. The bulb is conical in the upper half and rounded below, 6–7 cms. high, 4–4·5 cm. broad from front to back, and 4·5–5 cm. broad from side to side. The disc at the apex is deep purple-brown, and the remainder of the bulb pale yellow, or yellow-green, reticulated with purple-brown veins. The wall is thin, not ridged, and the window area is visible externally at the apex, though not as clearly as in *Aristolochia ridicula.*

The tube leaves the bulb on the lower third of the anterior side, the wall of the bulb being invaginated above it, and, after a length of about 3 cm., divides into an upper and lower part, the latter forming a beak up to 24 cm. long, with an extreme depth of 2·5 cm., and the upper part a standard 8 cm. long, expanded at the apex. The bore of the tube is vertically oval, about 1 cm. by 6 mm. ; it is lined with white, hinged hairs, perpendicular to the wall, arranged in longitudinal rows, but not directed backwards. The hairs are about 1·2 mm. long.

The beak (Plate IV., fig. 3) is V-shaped in section, with slightly recurved edges. It is lined throughout with white, hinged hairs, about 2 mm. long. These hairs have a slight backward curve. The position of the enlarged base of the hair varies; at the upper edge of the beak it is parallel to the edge, but lower down it becomes oblique, and finally perpendicular to the length of the beak with the hinge on the inner side. Hence a fly which enters the beak from the edge can advance most easily obliquely downwards to the bottom and thence towards the bulb. The bases of the hairs are situated with their long axes perpendicular to the veins on the walls of the beak; hence the gradual change in their position relative to the length of the beak. The exterior of the beak is almost entirely purple-brown, very little of the green ground colour being evident. Internally it is pale green.

On wet days the open beak collects rain water, which runs back into the bulb, and the latter may be half filled.

The standard is about 8 cm. long. It is about 1·3 cm. broad below, and enlarges above gradually into a sub-circular expansion, about 4 cm. in diameter, slightly incised at the apex. The sides of the narrower part and the lower edge of the terminal expansion are strongly recurved. The colour of the back or upper side of the standard resembles that of the exterior of the beak, being strongly veined with purple-brown; the lower side is green over the narrower part, and veined with purple-brown on the terminal expansion, the colour being fainter than on the upper side. A strong prominent median vein runs on the upper surface along the whole length of the standard, giving off prominent lateral veins, while the lower surface is deeply medially grooved. White hinged hairs cover the lower surface of the standard from its base over all the narrower part, and extend over the base of the terminal expansion. The flower has a faint odour of fæces, and this emanates from the terminal expansion of the standard only.

Of the six main veins which traverse the bulb and tube longitudinally, the three upper proceed to the standard; the middle one of these forms the median vein of the standard, while the other two divide up and thin out without reaching the terminal expansion. Of the three lower, the middle one runs along the lower edge of the beak, while the other two run as prominent ridges, one on each side of the beak along its whole length, a short distance from the base, giving off oblique branches towards the upper edge. But before it reaches the beak, each of the latter two gives off a branch which proceeds to the standard. The arrangement of the main veins, as support for the standard and beak, is consequently similar to that which obtains in *A. gigas*, with the addition of the median upper vein along the middle of the standard. Thus, as far as the arrangement of the veins is concerned, the beak of *A. ringens* corresponds to the tail of *A. gigas*.

The gynostegium is six-lobed and resembles that of *A. ridicula*, but the fillet round the edges of the lobes is medially grooved along its whole length. The window area round the gynostegium is bordered below by a narrow, purple-red line.

Internally, the wall of the bulb below the window area is slightly woolly-tomentose to a depth of 1 cm. This is succeeded by a glabrous zone, 1·5–2 cm. wide, and this, in turn, by another woolly-tomentose zone at the base. Round the inner end of the tube the wall is glabrous in a zone, 7 mm. wide above, which thins off gradually on either side; as usual, the wall is strongly thickened over the upper part of this glabrous zone. Above that are two symmetrically placed, closely tomentose, white, food areas, separated by a narrow, vertical, glabrous line (Plate IV., fig. 2).

The flower opens at daybreak. In a flower which opened on February 10 the beak had opened, and the standard had opened but was not fully expanded, at 6.20 A.M. Sunrise on that date was at 6.30. On wet days, or if rain falls in the afternoon, it closes about 4.30 P.M., but on fine days the closure may be delayed until 5 P.M. or later. The two sides of the beak approach one another, and the edge of one curls over the other. Subsequently, the standard curls over below the beak, into the position normally occupied by the standard of *A. hians.* The entrance to the tube is consequently hidden by the narrow part of the standard, but it is not completely closed. The decurved standard is rigid, not collapsed.

During the night the anthers open. The teeth of the gynostegium are then only slightly incurved, and their position is practically unchanged on the third morning. Complete closure of the gynostegium does not occur until the fourth morning, two days after the pollen is liberated.

The hairs in the tube wither between 8 and 9 A.M. on the second morning. In the majority of the cases examined, they withered before 8.30 A.M. But the flies do not escape immediately the hairs wither. Flies are generally found at 8.30 A.M. and 9 A.M. in flowers in which the hairs have withered. In one instance a fly was found to remain in a flower until about 12 noon, escaping between that time and 2 P.M.; while in another a fly was found in a flower at 4.30 P.M. on the second day.

The flies do not appear to escape readily from this flower. There is no change in the position of the standard after it has once curled over, and the sides of the beak do not separate again. Consequently, the only exit is a small opening about 2 mm. diameter at the base of the standard, where the edges of the beak do not meet one another; and this is to some extent hidded by the narrow part of the decurved standard. When the hairs in the tube have withered, an insect which ascends the tube finds a wide oval passage immediately in front of it down part, at least, of the closed beak, while the way out is situated above this. It is possible that the insects may not find the small upper opening, until the walls of the beak have come flat together.

In flowers gathered at 4.30–5 P.M. on the day of opening, flies have been found up to the number of fourteen in a single flower. But sixty flowers gathered at that time on different dates yielded only 125 flies, and five per cent. of the flowers did not contain any. The greatest number of flies in a single flower was 14. Nine flowers gathered between 8 and 9 A.M. on the second day contained

12 flies only; four of these did not contain any, though the hairs had not withered. Nearly all the flies found in the flowers on the second morning bear pollen.

Among the miscellaneous insects found in the flowers of *A. ringens* were several species of ants, one example of a coleopteron, and one example of each of two species of *Microlepidoptera.* A collection of 136 flies contained thirty-three species. *Rivellia basilaris* Wd., represented by 62 examples, *Limosina punctipennis* Wd., 6 examples, *Lonchæa excisa* Kort., 14 examples, *Musca lineata* Brun., and *Euprosopia* sp., 3 examples, have not been taken in any other flowers. *Plagiostenopterina ænea* F., 3 examples present, and *Chrysomyza ænea* Fab., 4 examples, occur also in *A. sp. indet.* A *Discomyza*, 2 examples present, has been found also in *A. leuconeura. Aphiochæta* sp., 4 examples, occurs also in *A. ridicula*, *A. leuconeura*, and *A. elegans.* An Anthomyid which is the chief visitor to *A. gigas* was present to the number of 12. But of the thirty-three species, twenty have not been identified in any other flower. Twelve of these twenty, however, were represented by single examples only.

The principal species in the collection referred to are *Rivellia basilaris* (26), *Lonchæa excisa* (14), an Anthomyid (14), and an undetermined species (14). These four together form half the total. No *Sarcophaga* were present. The most striking feature is the occurrence of *Ortalidæ*, these numbering 41, or thirty per cent.

Though comparatively few flies visit *Aristolochia ringens*, isolated plants at Peradeniya fruit abundantly. After the flower falls the ovary turns upwards and assumes a vertical position, curving back again and becoming horizontal about a fortnight later. A fruit which set on November 15, 1918, was fully ripe and dehisced on February 28, 1919. Seeds planted on July 25, 1918, germinated on November 4, 1918.

A plant in my garden came into flower in February, when no other species were in bloom. The first flower produced a fruit. In March it flowered again under similar conditions, and five flowers opened on one branch at intervals of 2, 3, 2, 2 days, respectively; the first of these produced a fruit, but the succeeding four did not. As the flowers collapsed on the second day, it would appear that this species can be self-fertilized.

The bulb of *A. ringens* blackens strongly when placed in a cyanide bottle. But of two flowers so treated at the same time, one of which had opened that day and the other on the previous day, the former blackened while the latter did not.

SUMMARY.

The flower of *Aristolochia ringens* opens at daybreak. The pollen is liberated during the following night, and the hairs wither between 8 and 9 A.M. on the second morning.

The beak of the flower closes at about 4.30 P.M. on the first day, and the standard, which is at first erect, curves downwards to one side of the beak during the night.

The number of flies found in the flower at Peradeniya is comparatively small, sixty flowers yielding an average of two. Fourteen flies have been found in a single flower.

Flies are attracted to the flower by its odour, which emanates from the standard.

The beak of the flower does not re-open on the second day, and only a small aperture is left for the escape of the flies.

The gynostegium is not closed at the time the pollen is liberated.

Food is provided within the bulb for the imprisoned flies.

Thirty-three species of flies have been found in the flowers. Thirty per cent. of the flies belonged to the *Ortalidæ*. No *Sarcophaga* were present.

Isolated plants of *A. ringens* produce fruit in abundance.

Aristolochia sp. indet.

A species cultivated at Peradeniya, which has not yet been identified, is very similar in appearance to *Aristolochia ringens*, and, indeed, matches the figure of the latter in Botanical Magazine, Plate 5,700, in colour, more closely than the plant cultivated at Peradeniya as *Aristolochia ringens.* The ground colour is pale green, and the veins, as a rule, are not so strongly nor so broadly marked as in *Aristolochia ringens*, hence the flower is usually pale green with narrow, purple-brown markings, though in this respect it is variable, and some plants have flowers as dark as those of the latter species.

The general details of the two flowers are the same, but the following points of difference are evident. In this species the bulb is more conical, the anterior face being straighter, and the anterior lower edge obtusely angular, not rounded. The length of the bulb is 7–9 cm., its extreme breadth, from the back to the base of the tube, 6–7 cm., and its breadth from side to side 3·5–5 cm.; it is thus larger than that of *Aristolochia ringens.* On the other hand, the beak is shorter, and attains a length of 15–19 cms., while its tip is often furnished with a thin appendage about 1·5 mm. long. The tube bends backwards more than in *Aristolochia ringens*, and the wall of the bulb above it is more deeply invaginated.

From *A. hians*, as figured in Curtis's Botanical Magazine, Plate 7,073, it differs in colour, and in the absence of ribs on the bulb, while the wall of the bulb internally is not glandular. It does not appear to agree with any known species, and it is possible that it is an accidental hybrid between *A. ringens* and *A. labiosa.*

The standard is about the same length in the two species, but in this unidentified species the lower part is narrower (9 mm.), and it expands more abruptly above. The hinged hairs ascend only half way (2 cm.) up the narrow part, as a rule, though in some cases a few occur up to the expansion. The standard is usually not erect, but bends over and downwards on one side of the beak (Plate IV., fig. 6); in wet weather, however, it may be sub-erect and median. The general position of the standard in this species is that of the second day position in *Aristolochia ringens.*

The interior of the bulb is the same in the two species, the red line bordering the window area being broader in the undetermined species.

The odour of the flower resembles that of decaying, fish but it is only faint. As in *A. ringens,* it emanates from the standard.

The behaviour of the flower resembles that of *Aristolochia ringens,* but it closes later in the day as a rule. It opens at daybreak; on May 4 a flower was opening at 5.45 A.M., sunrise on that date being at 5.56 A.M. On two occasions it was observed to be closing at 4.30 P.M., though it more usually begins to close about 5 P.M.; but the sides of the beak have not completely met before dark (6.30 P.M.). The hairs usually wither before 8 o'clock on the following morning, but in one instance they had not withered at 9.15 A.M.

The plants under observation at Peradeniya bore very few flowers, and consequently it has not been possible to make many observations on this species. Twenty-nine flowers gathered on different dates at 5.30–6 P.M. on the first day contained 113 flies; six did not contain any. The maximum number of flies in a single flower was 12.

A collection of 60 flies from the flowers included nineteen species. In addition, several ants were found and one bee (*Melipona iridipennis* Dall.). The most numerous fly was an Anthomyid, which occurred also in *A. gigas* and *A. ringens;* it formed nearly a quarter of the total. *Plagiostenopterina ænea* F. and *Chrysomyza ænea* F. were represented by two examples each. One *Sarcophaga* was present. Of an *Ophyra* sp., taken also in *A. ridicula,* there were seven examples. Two other undetermined species occurred to the extent of eight and nine examples, respectively, the former having been found also in *A. leuconeura* and *A. gigas.* Eight other species were represented by single examples. *Ortalidæ* were present to the number of five.

This species has not been known to bear fruit at Peradeniya. The two plants under observation were isolated examples, about a mile distant from one another.

SUMMARY.

This species closely resembles *A. ringens* in habit and structure. Its standard is usually decurved to one side of the beak before the flower opens and does not assume an erect position.

The flower opens at daybreak. The pollen is liberated during the following night, and the hairs usually wither before 8 A.M. the next morning.

The beak begins to close about 5 P.M., but the sides have not met completely before dark. It does not re-open on the second day.

Food areas are present within the bulb.

The gynostegium is not closed at the time the pollen is liberated.

This species flowers sparingly at Peradeniya. Isolated plants do not produce fruits.

The maximum number of flies found in a single flower was twelve. Twenty-nine flowers yielded an average of four flies each ; six did not contain any flies.

A collection of 60 flies included nineteen species, an Anthomyid being the most numerous (14). One *Sarcophaga* was present. *Ortalidæ* formed eight per cent. of the total.

Aristolochia kewensis.

This is a garden hybrid between *A. brasiliensis* and *A. trilobata.* It is described and figured, with the parent plants, in the Gardeners' Chronicle, L (1911), pp. 300, 301, with supplementary plate. In general shape it approaches *A. trilobata,* differing in having the lower lip more produced and the standard broader. In *A. brasiliensis* the lower lip forms a long beak, while the standard consists of a short stalk and a broad subcircular expansion. In *A. trilobata,* the lower lip is scarcely produced, and the standard is long and narrow. In the hybrid, the lower lip is a little more produced that in *A. trilobata,* but not definitely beaked, while the standard is that of *A. trilobata,* but broader. It may be noted that in the illustrations referred to above, the gynostegium in all cases is shown in its second day stage.

A single plant has been grown at Peradeniya since 1913. Unfortunately there is no specimen of *A. brasiliensis* there for comparison. *A. trilobata* is present in the Gardens, but it does not flourish, and it has not been possible to extend observations to it. Comparison of the behaviour of these two plants with that of the hybrid would no doubt prove of interest.

The account of this plant in the Gardeners' Chronicle states that *A. kewensis* is the first hybrid *Aristolochia.* That overlooks the fact that Ule obtained a hybrid between *A. brasiliensis* and *A. macroura* (Ber. Deutsch. Bot. Gesell., xvii. (1899), p. 35). The two hybrids resemble one another fairly closely, according to the published figures.

The bulb and tube (Plate IV., fig. 5) resemble those of *A. ringens,* the colour being pale green with purple-brown veins. The apex of the bulb forms a socket, the edge of which is divided and produced into six horizontal or decurved teeth. The tube is rather strongly ridged along the principal veins, and especially along the dorsal vein which is continued up the centre of the standard. The bore of the tube is vertically oval, and measures about 10 × 8 mm. in the middle.

In *A. ringens* the upper half of the face—the standard—is comparatively short, while the lower half is produced into a long beak. In the present plant this is reversed. The tube expands into a funnel-shaped, somewhat spathulate mouth, about 3·5 cm. from front to back and 3 cm. wide, rounded in front, with an even, slightly decurved margin. The standard, on the other hand, is produced into a long purple-brown appendage, up to 20 cm. long, 4 cm. broad at the base, and 2·5 cm. broad near the apex.

In the bud the standard is folded along the mid-rib, the two halves being united by their edges, and the sides of the mouth are infolded and united along the median line as in *A. indica.* On expansion, the sides of the standard are strongly recurved, and the distal half is rolled up laterally. The standard hangs somewhat loosely over the mouth of the tube ; it is never erect.

The hinged hairs extend to the edge of the funnel, but do not ascend the standard. They are purple, 2–2·5 mm. long in the funnel, 1·6–1·8 mm. in the middle of the tube, and up to 3·5 mm. at the inner end. A wide space remains unobstructed by the hairs, and it would appear that flies should not have much difficulty in escaping from the flower.

The odour of the flower resembles that of *A. leuconeura.*

The interior of the bulb is woolly-hairy, with minute purple-red spots as in *A. ridicula* and *A. gigas,* except on a broad zone at the apex. The window area is bounded by the usual purple-red line. In this species the window area is well-developed and visible from the exterior. A pair of food areas is present above the thickened invaginated zone over the inner end of the tube ; they are more or less rectangular, purple, covered with matted moist hairs as in *A. ridicula.* The thickened zone bears irregularly scattered, brown, projecting points.

The flower opens about daybreak. On December 23 three flowers were open, and one in process of opening, at 6.10 A.M. ; sunrise on that date was at 6.17 A.M. The pollen is liberated during the next night, and the standard curves down so that the lower part is closely applied to the mouth of the funnel. At the same time the recurved sides of the standard flatten out towards the base, so that the mouth of the funnel is covered except for a narrow opening along either side. The hairs wither between 8.30 and 9 A.M. on the second day.

The imprisoned flies do not all escape as soon as the hairs wither. On one occasion, of four second day flowers gathered at 9 A.M., in all of which the hairs had withered, one did not contain any flies, while the others contained one, two, two, respectively. In another instance a fly was found in a flower at 4.30 P.M. on the second day.

The gynostegium is not completely closed at the time the pollen is liberated. On the afternoon of the second day the sides of the teeth have met, leaving a star-shaped opening at the apex. It closes completely on the third day, as a rule.

Twenty-eight flowers gathered on various dates at 4 P.M. on the first day contained in all seventy-six flies. The greatest number in a single flower was twelve. Five flowers did not contain any flies. Of the seventy-six flies, five were *Ortalidæ* and eight *Sarcophaga*. The remainder were not submitted for identification.

Only one plant of *A. kewensis* is grown at Peradeniya, and that has not been known to bear fruit.

SUMMARY.

The flower of *Aristolochia kewensis* opens at daybreak. The pollen is liberated during the following night, and the hairs wither between 8.30 and 9 A.M. the next morning.

Flies are attracted to the flower by its odour, which emanates from the standard.

On the second day the entrance to the flower is partly closed by the expanded base of the standard.

The gynostegium is not closed at the time the pollen is liberated.

Food is provided within the bulb for the imprisoned flies.

The average number of flies found in a flower was 2·6. The maximum in a single flower was twelve.

Several species of flies visit the flower, among them being *Sarcophaga* sp. and *Ortalidæ*.

An isolated plant at Peradeniya does not produce fruit.

Aristolochia fimbriata Cham.

A species cultivated at Peradeniya, which is believed to be *A. fimbriata*, is a small straggling plant about a foot and a half in height. In habit it resembles *A. bracteata*, and the position of the flower is the same as that of *A. bracteata* and *A. indica*. It differs from the description of *A. fimbriata* in that the flower is not greenish-brown externally.

The exterior of the flower is green or greenish-white, with dark green longitudinal lines along the bulb and tube. On opening, the limb curves back strongly, becoming convex and more less reniform (Plate V., fig. 1). The expanded limb is purple-brown or chocolate-brown in more or less rectangular bullate areas, separated by depressed yellow bands which correspond with the veins; it is fringed with linear processes, up to 7 mm. long, yellow with purple-brown tips, or yellow, purple-brown at the base and the tip, and along the anterior side. In the bud the processes are folded inwards inside the closed limb.

The anterior edge of the tube is incised. Internally the tube is purple, with darker purple longitudinal lines, corresponding to the dark green lines on the exterior. It is lined somewhat scantily with white hinged hairs. The thickened zone at the junction of the bulb and the tube projects into the bulb above the opening of the tube as a triangular ledge, and a moist food area is situated above the ledge. The wall of the bulb is woolly internally, pale green, with a few purple spots. The window area is well defined, and bordered by a diffuse dark purple zone with a definite upper edge. The gynostegium is six-lobed, the lobes being acuminate at the tip.

The flower opens at daybreak and is fully expanded before sunrise. No change is observable during the first day. During the next night the pollen is liberated, and the marginal processes bend inwards over the limb (Plate V., fig. 2). The teeth of the gynostegium do not curve inwards, and, consequently, self-pollination is possible. About half an hour after sunrise on the second morning the hairs in the tube wither and the flies begin to escape. Flies were seen to emerge at 6.25 A.M. on May 1, sunrise on that date being at 5.56 A.M. The escaping flies bear pollen on their backs. By 8.30 A.M. the face has become flatter, though the margin is still recurved, but by 10 A.M. the two halves have folded together in the same position as in the unopened flower, so that access to the interior is no longer possible. It then requires a close examination to distinguish the effete flower from an unopened bud.

The flies which visit this flower are chiefly *Drosophilidæ*. In a collection of 258 flies made from a plant in the Botanic Gardens in 1921, nearly the whole consisted of one species of *Drosophila*, but the exact number was unfortunately not ascertained. There were also present in small numbers two other species of *Drosophila*, *Leucophenga* sp., and *Phortica xyleboriphaga* White. Other species represented by few or single examples included *Sciara* sp., *Aphiochæta* sp. (different from those found in *Aristolochia floribunda*), ? *Ilythea* sp., *Lonchæa bisulcata* Bez., and a Chloropid. In flowers of a plant under observation in my garden in 1922 the flies were again *Drosophilidæ*. The flower is distinctly a Drosophilid flower.

The whole plant has a rank odour like that of *Aristolochia ridicula*. Of fifty-one flowers gathered at 4 P.M. on their first day, 14, or 27·5 per cent., did not contain any flies. The total number of flies was 258, or an average of 5 flies per flower. The greatest number found in one flower was 35.

These observations were made on an isolated plant at Peradeniya, and very few flowers were available. In general, only one flower was open at a time, and only on one occasion out of twenty-nine were three flowers open. The records show a marked periodicity in the average number of flies per flower, as will be evident from the following data. All the flowers which opened during the period in question are included :—

September 11, 1921 : Two flowers ; 16 flies
September 13, 1921 : One flower ; 35 flies
September 14, 1921 : One flower ; 26 flies } average 18
September 15, 1921 : One flower ; 13 flies

September 17, 1921 : Two flowers ; 9 flies
September 18, 1921 : Two flowers ; 3 flies
September 19, 1921 : One flower ; 0 flies — average 1·9
September 20, 1921 : One flower ; 0 flies
September 21, 1921 : One flower ; 1 fly
September 22, 1921 : Two flowers ; 11 flies
September 24, 1921 : One flower ; 6 flies
September 25, 1921 : One flower ; 16 flies — average 10·2
September 26, 1921 : One flower ; 18 flies
September 28, 1921 : One flower ; 1 fly
September 29, 1921 : One flower ; 3 flies — average 1·2
September 30, 1921 : One flower ; 1 fly
October 1, 1921 : One flower ; 0 flies

There was no marked variation in the weather conditions during the period. It is probable that the variation is dependent upon the hatching out of successive batches of the insects. If that is the case, it leads to the conclusion, which might be thought obvious, that when an *Aristolochia* is visited by a limited number of species of flies, the average number of flies found in a flower during any particular period depends chiefly on the number of flies of those species in the immediate neighbourhood.

An isolated plant of *Aristolochia fimbriata* fruits freely at Peradeniya. Seeds sown on June 15, 1918, germinated on November 19, 1918.

SUMMARY.

The flower of *Aristolochia fimbriata* opens at daybreak. During the following night the processes at the margin of the face bend inwards and the anthers dehisce. The hairs in the tube wither about half an hour after sunrise.

After the flies have escaped the limb shrinks, and the two halves of the face fold together laterally so that they occupy the same position as in the unopened flower.

The teeth of the gynostegium do not curve inwards.

Thirty-five flies have been found in a single flower. In fifty-one flowers the average number of flies was five, and 27·5 per cent. did not contain any.

Nearly all the flies found in the flower at Peradeniya are *Drosophilidæ*.

The flower has no evident odour, distinct from the rank odour of the whole plant.

An isolated plant at Peradeniya fruits freely.

Aristolochia tricaudata Duch.

Aristolochia tricaudata, at Peradeniya, is a shrub of medium size, with a tendency to produce long, simple, sub-erect stems or branches. Its purple-red flowers (Plate V., fig. 4), though constructed on the general plan of bulb, tube, and hood, are remarkably different from those of the other species cultivated in Ceylon.

The bulb passes into the tube without any definite change of form, and the tube curves round and upwards parallel to the bulb. From apex to base the bulb is about 3·5 cm. in length. Shortly below the apex it is about 1 cm. in diameter; below that it contracts slightly, and then expands to a diameter of about 1·2 cm. at the base. Round the apex the colour is greenish white; this coloration ceases abruptly and is followed by a darkened region, due to the internal coloration of the bulb. The remainder of the bulb is white, sprinkled with minute purple-red points. The whole of the exterior of the flower is rough with very minute hairs.

The tube (Plate V., fig. 5) curves upwards for about one-quarter the height of the bulb. Its anterior edge then curves back sharply, but afterwards becomes vertical again above and then bends forward into the slightly oblique lip. A pouch is thus formed underneath the lip.

The posterior wall of the tube is not free, but is concrescent with the wall of the bulb up to about half the height of the latter, while the sides bulge out laterally.

The tube now expands into the limb or face, gradually, except for the abrupt fold at the lip. The face is hooded, deeply concave, incised at the upper edge, and divides into three long appendages. It may be regarded as composed of three long triangular segments, the two broader forming the sides and uniting above in the median line, whilst the narrower forms the lip. The free ends of these segments are up to 12 cm. long. The colour of the hood and appendages is deep red-purple, but the posterior part of the hood, in continuation of the inflated sides of the tube, is pale purplish-white.

The lip is elevated in the centre, and from it a paler area extends outwards. This area is minutely tuberculate. On either side of it the rim of the tube is pale reddish purple.

The concavity of the hood (Plate IV., fig. 7) is divided into two regions at the back by a broad vertical swelling, which, above, is an actual invagination of the wall, and, below, is the wall of the bulb. This swelling extends forward to the lip, leaving an open passage on either side into the tube.

There are no hinged hairs in the tube. The exclusion or admission of insects is governed by a complicated series of folds or ridges within the tube (Plate IV., fig 8).

The anterior wall of the bulb is continued downwards to about 3 mm. from the base of the flower, where it ends in a free edge. Opposed to this, are two tooth-like projections just below the lip on the strongly-thickened vertical portion of the wall of the tube (Plate IV., figs. 8 and 9). At the level of the free edge of the anterior wall of the bulb a broad sub-horizontal ridge (c) projects laterally on each side from the wall of the tube into the tube cavity. These ridges terminate in the hollow beneath the lip : their free edge is curved downwards.

There is considerable variation in the structure of the flower, as it grows in Ceylon, more especially as regards the lip. In what appears to be the most general case, the infolded wall which forms the lip is strongly thickened, and the inner surface of the tube just below the lip is vertical, flat, irregularly rugose, with two strong teeth projecting downwards from it, close together in the centre (Plate IV., fig. 9). In such cases the lateral ridges form a floor to the side passages, but the teeth do not meet them. Consequently it is possible for an insect to crawl over the ends of the ridges, and so into the bulb. In a few flowers, however, the lip is thinner and not so abruptly folded : it is indented in the centre (Plate V., fig. 6), and the two teeth appear as ridges, on either side of the indentation, which are produced below into rounded plates. These plates close the passages completely. In these flowers the tube is usually narrowed along the base of the flower.

The probable explanation of the mechanism of the flower would appear to be as follows. An insect attracted by the colour or odour finds the back of the hood and the side passages lighter than the anterior parts, and may consequently be induced to proceed further. The projecting wall of the bulb meets the lip in the centre and divides the mouth into two passages, and the insect crawling down one of these finds its path blocked by the lateral ridge which stretches across to the free edge of the anterior wall of the bulb, and forms, as it were, a floor to the passage. However, it would still be possible for it to proceed along the ridge into the part of the tube beneath the lip, except in those flowers in which this path is blocked by the tooth which projects downwards from the latter.

How this arrangement works, *i.e.*, how insects are admitted to the flower and allowed to escape, I have not been able to determine. The majority of the flowers developed at Peradeniya appear to be imperfect, and the relative position of the parts appears to be the same at all ages of the flower. As the teeth on the lip do not close the passages in the majority of the flowers, it is always possible for a small insect to enter the flower.

The window area at the apex of the bulb is comparatively broad. It transmits light into the interior, but it is not evidently translucent like the window area of *A. ridicula*. Externally it is indicated by the pale greenish white colour of the apex. Internally it is bordered by a broad red-purple zone, which has a definite margin above, but shades off indefinitely below. The remainder of the interior is white and glabrous: the usual *Aristolochia* covering of woolly hairs is absent.

The gynostegium (Plate V., fig. 7) is of the usual obconic type, but is divided above into three lobes only. The lobes are ovate, pointed at the apex, with a convex inner surface. Sometimes one of them is bifid at the apex. They are not bordered by a fillet, but the outer face is slightly concave towards the margin, and the margin projects as an acute border. The longitudinal sessile stamens are situated in pairs in the centre of the lobes.

The full expansion of the flower occupies several days. In the bud the appendages are in contact above, but strongly twisted together below. When the flower begins to expand the appendages begin to separate at the upper ends, causing narrow gaps through which small flies could enter. The next day the hood is fully expanded, but the tails are still twisted together. Each appendage now bends strongly outwards, and the tension created by this curving causes them finally to untwist. The two lateral lobes take up a horizontal position at right angles to the axis of the flower, with the thin appendages sometimes horizontal, sometimes twisted upwards, but in general, with the outer half pendent and twisted corkscrew fashion. This final untwisting may take place in the early morning on the third day, or it may be delayed until midday. At 8.30 A.M., on June 17, the tails were completely free in six flowers, while in two others they were still twisted together at the tips. These last two completed their expansion during the morning. Of the other six, in three the lateral tails were almost horizontal, while in the other three they were partly horizontal, with their ends twisted in corkscrew fashion. In a few hours, by midday if the flowers have opened in the early morning, the lateral lobes lose their rigidity, and fall into a more or less vertical position. The full expansion of the flower is not completed until the third day.

On the fourth morning, by 8 A.M., the anthers dehisce. The lobes of the gynostegium have then curved inwards, but have not met. As in *A. leuconeura*, the complete closure of the gynostegium does not occur until some time after the pollen is liberated, and in the present case it is a very gradual process which is prolonged into the fifth day.

The flowers have a faint sweet odour, but they do not appear to attract any insects at Peradeniya. I have never found anything in the flowers, though more than one hundred have been examined. No fruits have been observed on this species in Ceylon.

SUMMARY.

Aristolochia tricaudata differs from the other species dealt with in the present paper, in having a three-lobed gynostegium.

There are no hinged hairs in the flower, the admission and imprisonment of insects apparently being governed by a complicated series of folds or ridges within the tube.

The full expansion of the flower occupies several days, and it could apparently be visited by small flies for three days before the anthers dehisce.

No alteration in the relative positions of the ridges in the tube has been observed at Peradeniya, and it has not been possible to ascertain how the flower acts.

No flies have been found in the flowers at Peradeniya.

Only one plant of *Aristolochia tricaudata* was growing at Peradeniya during the time of these observations, and that has not been known to bear fruit.

GENERAL SUMMARY.

The flowers of the species of *Aristolochia* dealt with in this paper may be regarded as consisting of a bulb, an open limb or face, and a tube connecting these two.

The face may take the form of a shallow concave hood, single, as in *A. elegans*, or double, as in *A. gigas*; or be funnel-shaped, as in *A. leuconeura* and *A. floribunda*; or be deeply divided into a standard and an elongated beak, as in *A. ringens*; or reduced to two small wings, as in *A. ridicula*; or reduced to a standard only, as in *A. indica* and *A. bracteata*. In the beak of *A. ringens* the arrangement of its main veins is the same as that of the tail of *A. gigas*.

In the majority of these species the face is strikingly coloured and ornamented with radial lines which converge to the mouth of the tube. *A. indica*, *A. bracteata*, and *A. tricaudata* are exceptions to this rule, the standard being dull and uniformly coloured in the two former, while in *A. tricaudata* the hood is purple-red, paling towards the interior; in these three there are no guide lines to the mouth of the tube, but *A. indica* and *A. bracteata* have a coloured streak running vertically down within the tube on its anterior side.

[To simplify this summary, further reference to *A. tricaudata* is omitted. This species has no hinged hairs, entry into the bulb being governed by a series of ridges in the tube. It does not attract flies at Peradeniya, and consequently there has not been any opportunity of determining how its mechanism operates. It belongs to the section *Siphisia*, including species which have a three-lobed gynostegium; all the other species under notice have a six-lobed gynostegium.]

The tube is lined with hinged hairs directed slightly downwards. In *A. ridicula* the hairs practically close the tube in its lower half, but in *A. gigas* and *A. elegans* they do not meet, a wide central space being left unobstructed in the first of these. The base of the hair, in plan, is usually semi-elliptic, and the hair stands with the more convex side of the base towards the inner end of the tube. The actual base is free, the hair being attached by a short hinge about the middle of the more convex side. The free base is convex, and consequently the hair can rock from side to side, and be bent downwards towards the inner end of the tube, but it breaks off if pressed upwards towards the mouth. The hairs appear closely septate, but in *A. ridicula*, at least, some of the apparent septa are incomplete in the centre and form perforated discs.

Flies are attracted to the flowers by their odour. In *A. gigas* the smell is very offensive, and resembles that of decaying meat. *A. kewensis*, *A. leuconeura*, *A. ringens*, and *A. sp. indet.* have similar odours, but not strong enough to be offensive, while in *A. floribunda* the smell is scarcely perceptible. The flowers of *A. indica* and *A. bracteata* have no appreciable smell, unless bruised, and then it is merely that of the other parts of the plant under the same conditions. In *A. ridicula* and *A. fimbriata* the plant has a rank smell, but no other odour can be detected in the flower, while *A. elegans* has no appreciable scent either from the flower or the foliage. But it is easily demonstrated in the case of *A. ridicula* and *A. elegans*, that, although the human sense of smell fails to detect it, flies are nevertheless attracted to the flower by some odour it emits. In *A. floribunda* the face is covered with a viscid substance on which the flies feed.

The odour emanates from the face of the flower, from an area near the mouth in *A. gigas* and *A. leuconeura*, or from the standard in *A. kewensis*, *A. ringens*, and *A. sp. indet.* It is not perceptible in flowers artificially and prematurely opened, and in *A. gigas* it disappears towards evening on the day the flower opens. But the flower of *A. elegans* will attract flies on the fourth day, after it has fallen.

Though flies are attracted to the flowers by their scent, they appear to enter the tube merely by accident. In *A. ridicula* they would seem to mistake the white central area, formed by the marginal hairs of the tube, for a solid surface, and the arrangement may be compared to a pit-fall. In *A. elegans* and *A. gigas* the hinged hairs ascend partly over the concave surface of the hood round the mouth of the tube, and the flies which walk over that area are shot down the tube by the recoil of the displaced hairs. The hairs on the standard in *A. ringens*, *A. sp. indet.*, *A. indica*, and *A. bracteata* may serve a similar purpose. The beak in both *A. ringens* and *A. sp. indet.* is lined with hairs, and these are arranged in such a way that a fly which enters the beak would find it easier to crawl along it to the tube than to escape over the side ; but no instance of a fly alighting on the beak has been observed.

The wall of the bulb is usually invaginated above its junction with the tube, and the invaginated zone is strongly thickened. The thickening is greatest and broadest above the inner opening of the tube, and diminishes gradually down either side. This thickening would appear to be a mechanical device for maintaining the relative positions of the bulb and tube. But while it is smooth and regular in *A. elegans*, it becomes nodular in *A. ridicula*, is produced into a triangular ledge above the opening in *A. leuconeura* and *A. fimbriata*, and into a short tube, which projects into the bulb, in *A. gigas*.

At the apex of the bulb the wall is subtranslucent, and forms a "window area" through which light enters the bulb. The window area, though subtranslucent, is thicker than the remainder of the wall. In *A. ridicula* it is clearly visible from the exterior, but in the species which have more fleshy walls, *e.g.*, *A. elegans*, it is not evident externally, though it is readily seen when the bulb is cut open and held up to the light. This is one of the most efficient devices in the flower ; it ensures that the flies which enter the bulb will seek the neighbourhood of the gynostegium.

In some species the flower provides food for the imprisoned flies, which is secreted from two definite food areas. These food areas are symmetrically situated above the inner opening of the tube. In *A. ridicula* the two food areas form a conspicuously moist zone above the tube opening—the median line of separation being obscured ; the same occurs in *A. floribunda*, but in this species it is not so clearly evident. *A. leuconeura* appears to have two similar areas in the cavity formed by the prolongation of the invaginated wall, but this has not been determined with certainty. In other species the food areas differ from the remainder of the wall of the bulb in being minutely tomentose. *A. sp. indet.* and *A. ringens* have symmetrically-placed tomentose areas; and in *A. elegans*, *A. indica*, and *A. bracteata*, which have similar food areas, their position is indicated externally by the shape of the wall. In *A. elegans* the wall is depressed over the food areas, while in the other two species it is elevated. *A. gigas* does not appear to provide any food for the flies which it captures.

The remaining parts of the wall of the bulb are, as a rule, clothed on the inner side with long woolly hairs. In *A. sp. indet.*, *A. kewensis*, and *A. ringens*, this covering is not continuous, a broad zone in the upper part of the bulb being glabrous. In *A. gigas* the covering takes the form a fairly compact, velvety pile. As far as has been observed, this general covering of hairs does not furnish food, though in some cases, especially in *A. gigas*, it appears slightly viscid. In *A. gigas*, *A. kewensis*, *A. fimbriata*, and *A. ridicula* the covering of hairs is interrupted by small purple-red glabrous spots, and the window area in nearly all the species under consideration is bounded by a zone of the same colour; the significance of these coloured areas has not been determined.

The gynostegium is funnel-shaped and hangs in an inverted position from the apex of the bulb. It is deeply divided into six triangular lobes, and the margin of the lobes is at first bent outwards so that it forms a continuous fillet along the edge. The sessile anthers are situated one below each lobe, and in some species the upper ends of the anthers are partly hidden by the fillet. *A. indica* and *A. bracteata* do not adhere to this plan; in these two the six lobes are triangular-pyramidal and are seated on a disc, the edge of which is decurved and partly hides the anthers. In the species which have a funnel-shaped gynostegium the interior of the funnel is viscid. The germ tubes of the pollen grains grow superficially over the viscid surface, and pass through the canal at the apex of the funnel.

When the flower opens, the gynostegium is in the condition described above. During the following night the fillet curves back and the anthers dehisce. The position of the lobes may change, but this varies with the species. In *A. gigas* the lobes begin to bend inwards on the evening of the first day, and next morning they have met completely, so that the inner surface of the gynostegium is inaccessible. In *A. ridicula* the closure on the second morning is not quite complete; the lobes have met along their sides, but there is still a small opening at the apex of the gynostegium. At the other extreme there is *A. elegans,* in which the position of the lobes scarcely undergoes any visible change. The closure of the lobes of the gynostegium is a device to prevent self-pollination, and it is found that *A. elegans,* in which the lobes do not close, can be self-fertilized.

The pollen is not shed freely into the bulb. In dry weather it remains adherent to the anthers. In wet weather it is found on the second day on the wall of the bulb at the level of the gynostegium, provided that flies have been excluded; this suggested that it was forcibly expelled from the anthers. To test that theory, all the perianth was cut away from a flower of *Aristolochia elegans* at 5 P.M., only a disc at the apex being left. The ovary and gynostegium still attached to the plant were then fixed vertically by means of a cotton wool plug in a test tube, 15 mm. diameter and 13 cm. long, the interior of which had been smeared with glycerine. The tube was supported in a vertical position, independently of the plant. Rain fell soon after the operation had been completed, and during the greater part of the night. At 7 A.M. next morning the pollen was found to be closely adherent to the anthers, none having fallen into the tube. But as soon as the ovary was touched, the pollen fell straight down to the bottom of the tube. This scarcely harmonizes with observations on the uninjured flower, for in the latter, the pollen, when it does not fall, *e.g.*, in dry weather, will remain adherent to the anthers for some days, in spite of the movements of the flowers. The injury to the flower may have modified its normal behaviour, and consequently the experiment does not necessarily negative the theory that the pollen is ejected from the anthers in wet weather.

The flower opens in the early morning. *A. elegans* opens before it is light, but nearly all the other species open about daybreak. *A. leuconeura* is exceptional in not opening until about 9 A.M. During the first day the flower is open the stigmatic surface is receptive. The flies which enter the flower are unable to escape, because of the hairs in the tube, and are compelled to remain in until the hairs wither. *A. elegans* is an exception to this rule, for the flies which visit it can get out at any time. During the first night the pollen is liberated, and on the second morning the hairs wither and allow the flies to escape. In *A. leuconeura*, which opens late, the pollen is not liberated until about 9 A.M.

The flies which enter a flower will naturally seek the window area at the apex of the bulb, and will rest there, facing the light. Therefore, when the pollen is liberated, they receive it on their backs, and the emerging flies may be observed to be carrying pollen on the back of the thorax, in a position in which it is not easily got rid of. Pollen which falls on the legs, wings, &c., of a fly is usually cleaned off. If the fly with its load of pollen visits another flower, it will again seek the neighbourhood of the gynostegium, and will leave the pollen on it. It would seem that the bulk of the pollen would be deposited upon the fillet, which is minutely hairy, and it is probable that the recurving of the fillet conveys the pollen to the inner surface of the gynostegium.

The flies are not liberated on the second morning until after a new set of flowers (if such exist) has opened. Thus, in *A. ridicula*, the flower opens about 6 A.M., and the hairs wither next day about 8 A.M. In *A. leuconeura* the corresponding times are 9 A.M. and 11 A.M.; in *A. indica*, 6 A.M. and 11 A.M. In *A. gigas* the times approximate more closely, the flower opening about 6 A.M., and the flies escaping next day before 7 A.M., while in *A. fimbriata* the times are about 5.45 and 6.30 A.M., respectively. But in all cases the efficient duration of the flower is rather more than twenty-four hours.

In *A. ridicula* the position of the flower changes during the first night, so that the entrance to the tube becomes oblique, and at the same time the wings of the face flatten; subsequently, the wings curve over towards the mouth. In *A. indica* also the position of flower changes, and the tube, which was vertical on the first day, becomes horizontal or directed obliquely downwards. It might be thought that these changes serve to indicate that the pollen has been liberated, but the behaviour of other species would appear to negative that supposition. In *A. leuconeura* the position of the flower changes before the pollen is liberated. In *A. gigas* the odour of the flower disappears on the evening of the first day. In *A. sp. indet.* and *A ringens* the beaks begin to close between 4 and 5 P.M. These changes prevent or hinder the visits of flies, but they are not necessarily dependent upon other changes in the flower. In all cases the alterations in position, odour, &c., are independent of pollination. Changes in position are brought about by a curvature of the ovary.

It is not clear why the flies emerge from the flower as soon as the hairs wither. In *A. gigas* the flies which are more or less normal, emerge when the hairs wither, but very many die in the bulb on the first day, and others are too dazed to escape on the second morning. Attempts to prove that the flies are driven out by some emanation from the flower have failed, and it has been observed that flies will visit the flower of *A. elegans*, after it has fallen on the fourth morning. One is compelled to fall back upon the somewhat unsatisfactory conclusion that the flies escape as soon as they can. But here again, *A. elegans* constitutes an exception: the flies which visit it can escape at any time, but, as a whole, they do not emerge until after the pollen has been liberated on the second morning, and they then emerge at, or shortly after, daybreak, *before the hairs have withered.* A biochemical investigation of the changes which occur in the *Aristolochia* flower might throw some light on this point.

Aristolochia, in Ceylon, usually flowers during wet or showery weather. It may be noted that the flowers of several of the species under observation are ill adapted for blooming in wet weather; in *A. ridicula, A. leuconeura, A. floribunda, A. ringens*, and *A. sp. indet.*, the bulb often becomes partly filled with rain water. On the other hand, they require an abundant supply of water to maintain the rigidity of the flower and the turgescence of the hairs. If periods of hot, dry weather occur during the flowering season, the hairs may wither, or the flower may collapse, on the first day, and in consequence the mechanism of the flower is rendered abortive.

According to the generally accepted view, the flowers of *Aristolochia* are protogynous, and their structure and behaviour constitute an elaborate arrangement for ensuring cross-fertilization. That view has been challenged by Burck, who examined *A. barbata* in Java and came to the conclusion that the flowers were self-fertilized, the imprisoned flies merely transferring pollen from the anthers to the stigma of the same flower.

Burck held that in *Aristolochia* the stigma and style had degenerated, but, on the other hand, the stamens, or rather their connective tissue, had fused laterally into a six-toothed hollow cone. The so-called gynostegium is consequently a "connective tube." To compensate for the loss of the stigma and style, the six teeth bend inwards until they meet laterally, and the hollow of the cone is thereby converted into an artificial stylar canal. This occurs at the time the pollen is liberated, and the flower is self-pollinated by the flies wandering about within the bulb.

In Burck's figure of the gynostegium of *A. barbata* at the time the anthers have dehisced, the six lobes are shown meeting laterally and forming a cup with a crenate margin. It is not clear why the gynostegium in that stage should be capable of functioning as a stylar canal better than when the lobes are separate.

Burck also objected that if any of the emerging flies entered another flower, the pollen which might be adhering to them would be brushed off by the hairs in the tube. He also, as another objection, propounded the query, what becomes of the first flower.

Burck's view of the function of the gynostegium cannot stand as a generalization applicable to all species of *Aristolochia*, *e.g.*, it would appear to be inapplicable in the case of *A. indica*, and other species with a similar gynostegium. In *A. ridicula*, at the time the pollen is liberated, the lobes of the gynostegium have incurved so that their edges touch, but there still remains a small star-shaped opening at the apex, as a rule; in this species, therefore, Burck's artificial stylar canal might be operative. In *A. gigas*, however, the gynostegium is completely closed at the time the pollen is liberated, and the blackening of the edges of the lobes indicates that the closure is a process of withering. In the other species considered in this paper, the lobes of the gynostegium have not met laterally by the time the pollen is liberated, and in some, *e.g.*, *A. elegans*, *A. floribunda*, and *A. fimbriata*, they never do meet; in these, therefore, the artificial stylar canal does not exist when the pollen is liberated.

In *A. gigas*, self-fertilization is impossible. In *A. ridicula* it does not occur, though this species shows a well-developed "artificial stylar canal." In all the other species considered, self-fertilization may be possible, provided the stigmatic surface continues receptive, because the gynostegium is not closed, *i.e.*, because the stylar canal is not formed, at the time the pollen is liberated. Burck's explanation of the changes of the gynostegium must, consequently, be discarded.

It has been shown in the course of the investigations described in this paper, that the flowers of *A. ridicula* can be fertilized on the first morning they are open, before the anthers dehisce; this species is therefore protogynous. Pollination experiments with *A. gigas* have been unsuccessful, but, from its structure, it certainly cannot be fertilized on the second day. On the other hand, *A. elegans* can be self-fertilized, that is, its stigmatic surface continues receptive until the pollen of the same flower has been liberated; but it would appear that cross-fertilization, before the pollen of the flower is liberated, is the more general.

Burck does not appear to have made any attempt to ascertain the course of events in *A. barbata*, and his ingenious conception is opposed to facts which are readily observable in other species. According to his view, *Aristolochia* flowers should invariably produce fruits, if they have been visited by flies. That is certainly not the case in Ceylon.

The following field notes have been made, bearing on the question of self-sterility. They are the results of observations extending over several years, but refer only to the behaviour of the plants under the conditions prevailing at Peradeniya

Isolated plants of *A. ridicula* do not bear fruit, though the flowers are visited freely by insects. From 1921, seven plants of the same clone (A) were grown over the same trellis in the flower garden in the Botanic Gardens, Peradeniya, but no fruits have been produced. From 1922, two plants of another clone (B) have been grown together at my bungalow, with the same result. From January of the latter year, two plants, one of each clone, were grown together near the Laboratory in the Botanic Gardens, and fruits were produced in September. This last result confirms the results of cross-fertilization between these clones.

Isolated plants of *A. gigas* do not produce fruits, but if two plants are grown together fruits are produced. This has been observed in the case of two plants which were believed to belong to the same clone.

Isolated plants of *A. elegans* fruit abundantly.

A. floribunda flowers somewhat sparingly at Peradeniya, but isolated plants fruit rather freely in comparison with number of flowers.

Isolated plants of *A. leuconeura* fruit very sparingly, though they flower abundantly. It is probable that this species is almost self-sterile.

Isolated plants of *A. ringens* fruit abundantly.

A. sp. indet. flowers sparingly, and an isolated plant at Peradeniya has never been known to fruit. It is situated a few yards away from the plant of *A. ringens*, and the two apparently do not cross. It is possible that this plant is a hybrid, perhaps of *A. ringens* and *A. labiosa.*

Isolated plants of *A. kewensis*, a hybrid, do not fruit.

An isolated plant of *A. indica* at Peradeniya flowered profusely, but fruited sparingly. In this case it is probable that the particular insect which visits *A. indica* did not occur in any abundance in the vicinity.

An isolated plant of *A. fimbriata* fruits abundantly.

Attempts to fertilize *A. gigas* with pollen from flowers of the same plant have been unsuccessful. Similarly, twelve attempts to fertilize the flowers with pollen from the flowers of another plant of the same clone have failed.

A. ridicula cannot be fertilized with pollen from flowers of the same plant. Fertilization, however, readily occurred when pollen from the flowers of a plant of clone A (see above) was applied to the stigmas of flowers of a plant of clone B on the morning the flowers opened. Four fruits were obtained in that way. But the seeds, though to all appearance perfect, did not germinate. Seeds from the natural cross germinated.

A plant of *A. ringens* at my bungalow came into flower in February, 1920, when no other species was in bloom. The first flower produced a fruit. It came into flower again in March under the same conditions, when five flowers on the same branch opened at intervals at 2, 3, 2, 2 days, respectively. The flowers collapsed on their second day. The first flower produced a fruit, but the remaining four did not. As the first flower collapsed before the second opened, and the pollen of the second flower was not liberated until three days after the first flower opened, it would appear that the first flower was undoubtedly self-pollinated. The fruits ripened in May, and, in my absence on leave, were collected by Mr. C. H. Gadd, who tested the seeds immediately, but did not succeed in germinating them. On my return to Ceylon in 1921 the remaining seeds were examined, and it was found that the embryo was perfect. Samples were sown on May 26, 1921, some in their natural condition, others after clipping away one side sufficiently to expose the endosperm. They were kept under observation until May, 1922, but none of them germinated. Seeds collected at random from an isolated plant of *A. ringens* germinated in about three months.

It has been shown that *A. elegans* can be self-fertilized; of seven bagged flowers artificially selfed, three produced fruits. It has also been shown that the first flower which opens may produce a fruit, although it may have fallen before the next flower opens. Further, if flowers are blocked with cotton wool on the evening of the first day, so that the flies cannot escape and pollen cannot be transferred from one flower to another, they may produce fruits. Cases have also been recorded in which a second flower must either have been self-fertilized, or fertilized with pollen from a flower which had collapsed and revived.

It is evident from the foregoing results that all grades of self-sterility or self-fertility may be expected within the genus.

The germination of the seeds of *Aristolochia* is usually delayed, but in all the species in which seeds collected at random have been tested, *i.e.*, with all the species dealt with here except *A. gigas*, *A. kewensis*, *A. sp. indet.*, and *A. tricaudata*, of which no seeds were available, it has occurred in less than six months. I am unable to offer any reason for the failure to germinate the seeds obtained by artificial cross-fertilization in *A. ridicula*, and by self-fertilization in *A. ringens.* The seeds appear to be quite normal and contain a well-developed, perfect embryo.

Maillefer (Archives Sci. Phys. et Nat. Geneva, vol. 46, pp. 91, 92 (1918)) has recently called attention to the occurrence of supposed parthenocarpy in *Aristolochia Sipho.* He states, however, that though the fruits appeared to be normal, all the seeds (graines) were reduced to a spongy mass without anatomical differentiation. The case is, therefore, quite different from that of the fruits obtained by self-fertilization in Ceylon.

Burck's query as to the fate of the first flower does not admit of a single comprehensive answer. If the flower is self-fertile, as in *A. elegans*, it may produce a fruit, though it more usually does not. But in general, it may be said that the first flower of an *Aristolochia* does not produce a fruit. Moreover, the same fate is likely to befall successive flowers borne on an isolated plant before it branches, since cross-fertilization between these flowers is to some extent prevented by the interval which elapses between the opening of successive flowers on the same stem.

Ule recorded that a cultivated plant of *A. brasiliensis* Mart. & Zucc. (=*A. ornithocephala* Hk.) under his observation never bore fruit, though the plant fruited freely in a wild state. He found flies in only seven flowers out of ninety-six examined, and concluded that the fly which visited the wild plant did not exist in the vicinity of the cultivated one. It is possible that, in its native habitat, *A. brasiliensis* is pollinated by one particular species of fly, and, in that case, Ule's conclusion might be correct; but there is also the possibility that *A. brasiliensis* is self-sterile.

The Insect Visitors.

One of the original objects of this investigation was a comparative determination of the insects which visited the different species of *Aristolochia*. It has not, however, been possible to carry that out completely, as little appears to be known about the *Diptera* of the tropics and many of the species taken are unnamed.

In addition to the *Diptera*, other insects may occur in the flowers in small numbers. These are no doubt to be regarded as accidental visitors. Among these were, *Coptosoma siamica* Wlk., *Ditoneus scabripennis* Mots., *Formicomus obscurus* Pic., and *Plateros dispellens* Walk., in *A. ridicula*; a coleopteron and two species of microlepidoptera in *A. floribunda*; a coleopteron in *A. kewensis*; and a bee, *Melipona iridipennis* Dall. in *A. sp. indet.*

Ants are found in the flowers fairly frequently. Among these the following species have been identified: *Technomyrmex albipes* Smith, *Plagiolepis longipes* Jerd., *Sima allaborans* Walk., *Tetratramorium simillimum* Sm., *Myrmicaria brunnea* Saund., *Leptogenys* (*Lobopelta*) ? *processionalis* Jerd. It would appear that these are also to be regarded as accidental visitors, the particular species found depending on what species have a nest in the immediate neighbourhood of the plant. Some, *e.g.*, *Technomyrmex albipes*, are probably attracted by the flies. But in the case of *A. elegans*, ants are attracted by the flower; when a flower has been enclosed in a bag prior to opening, *Technomyrmex albipes*, and a small red-brown species, will swarm over the bag immediately the flower opens, though they do not attempt to visit it before that.

The numbers of different species of Diptera which have been recognized among the insects collected from the different flowers of *Aristolochia* which have been examined are as follows :—

A. ridicula	60	*A. fimbriata*	11
A. gigas	18	*A. ringens*	33
A. elegans	3	*A. sp. indet.*	19
A. leuconeura	13	*A. indica*	1
A. floribunda	10	*A. bracteata*	1

It is probable that the above numbers are too low, especially in the case of *A. ridicula* and *A. gigas*, owing to the difficulty of distinguishing between closely-allied species.

The figures indicate that the majority of the foreign species of *Aristolochia* cultivated in Ceylon attract a miscellaneous assortment of flies. On the other hand, the native *A. indica* and *A. bracteata* are visited only by a single species. Thus, the Ceylon species are adapted to one fly, while the foreign species are not. Whether the latter have a more limited range of visitors in their native habitats is a point on which no information appears to be available; the observations made by Hart on *A. gigas* in Trinidad would indicate that they have not.

The condition of affairs in *A. elegans*, one of the introduced species, approaches that of the native *A. indica*. Of 504 flies taken from the flowers of *A. elegans*, 502 belonged to one species. Practically, *A. elegans* in Ceylon finds itself adapted to one particular fly. But, though it does not affect the point under consideration, it must be noted that in other respects *A. elegans* cannot be regarded as an efficient example of the *Aristolochia* type of flower; the flies, both in Ceylon and Brazil, can escape at any time, and, in Ceylon, they usually do so before the hairs wither.

The diameter of the bore of the tube naturally imposes a size limit to the flies which can enter a flower. In the case of *A. gigas*, *A. ridicula*, *A. kewensis*, *A. sp. indet.*, and *A. ringens*, the bore of the tube is wide, and the largest flies can enter easily. The largest flies which visit *Aristolochia* flowers in Ceylon, species of *Sarcophaga*, have been taken frequently in the first three mentioned, and once in *A. sp. indet.*, but have not been found in *A. ringens*.

In *A. floribunda* and *A. elegans* the bore of the tube is much narrower. But its narrowness should not be an obstacle to the majority of the flies which are found in other flowers. The flies which have been taken from the former, however, include species much larger than the visitors to *A. elegans*. In *A. leuconeura* the bore is still further reduced; yet thirteen species of flies have been found in it, as against only three in *A. elegans*. A large *Sarcophaga* has been seen on the funnel of *A. leuconeura*; this affords an example of the exclusion of particular flies by the size of the tube. *A. indica* has a tube of small bore, less than that of any of the introduced species, and only very small flies can enter the flower. But on the whole the size of the tube is not the only operative character in determining what species visit particular flowers.

It would be expected that the odour of the flower would be a dominant factor as regards the species of flies which visit it, and there are indications that such is the case. *A. gigas*, which has a strongly offensive odour of decaying meat, is the only species which attracts *Lucilia* sp. and *Chrysomyia* spp. But *A. floribunda* attracts flies which have not been found in *A. leuconeura*, though the odour of the two appears to be the same.

One remarkable feature is the occurrence of *Ortalidæ* in *A. ringens*, *A. sp. indet.*, and *A. kewensis*, commonly in the first of these and more sparingly in the second and third. Species of this family have not been found in any other *Aristolochia*. The odour of the last is apparently the same as that of *A. leuconeura*, in which these flies did not occur, while the odours of the first two differ from that and from one another. Scent does not appear to be the determining factor in this case. It may be noted that these three are "beaked" species, *i.e.*, either the upper or the lower lip is greatly produced.

The principal visitor to *Aristolochia floribunda* is a Trypetid which has not been found in any flower, while the flies which visit *Aristolochia fimbriata* are almost entirely *Drosophilidæ*.

As the insect population of the flowers is a mixed one, it might be expected to vary with the locality. On this point little evidence is available. The observations recorded were carried out at Peradeniya, either on plants in my bungalow garden, or in the Botanic Gardens about a mile distant. In the former, *A. ridicula*, *A. gigas*, *A. elegans*, *A. floribunda*, *A. fimbriata*, *A. sp. indet.*, and *A. indica* were grown close together. In the latter, *A. gigas*, *A. ridicula*, *A. elegans*, *A. ringens*, *A. sp. indet.*, *A. leuconeura*, *A. fimbriata*, and *A. floribunda* grew within a short distance of one another in the flower garden; *A. indica* and *A. leuconeura* together near the laboratory; and *A. kewensis* in the herbaceous garden. No difference was observed in the flies found in the same species of *Aristolochia* in the two localities. The particular Trypetid found in *A. floribunda* at the bungalow occurred in the same flower in the Botanic Gardens, and *A. fimbriata* attracted *Drosophilidæ* in both localities.

Similarly, the fly found in *A. indica* at Peradeniya is the same as that found in *A. bracteata* at Jaffna and Batticaloa. In the two latter localities flies occur frequently in the flowers, but at Peradeniya comparatively few were found in them. It would appear probable that the particular fly which visits the native species of *Aristolochia* is not abundant at Peradeniya. *A. indica* does not seem to be common at Peradeniya, while *A. bracteata*, being rather a sea coast plant, does not occur there.

There is evidence of a variation in the species of flies which visit some *Aristolochia* flowers in Ceylon, according to climatic conditions. In the case of *A. ridicula*, *Lonchæa* predominates in fine weather, and *Sarcophaga* during rains.

It was originally intended to show in tabular form the numerical relation between the different species of flies and the different *Aristolochia* flowers. That has, however, proved impossible, owing to the difficulty of obtaining identifications of many species, and also because the preliminary sortation, though correct as to genera, was not always complete as regards species. Thus, though the number of examples of (say) *Lonchæa* in a given collection is correctly stated, the numbers of the different species of *Lonchæa* in that collection are not always accurately known; and it is in some cases uncertain whether the particular species of *Lonchæa* found in one flower is identical with the species found in another, as it was at first believed to be. It has been considered preferable, therefore, to adopt the following arrangement.

Sarcophagidæ.

Sarcophaga spp. (or allied genera) have been found in *A. ridicula* (197 in 2,546 flies), *A. gigas* (155 in 1,325), and *A. sp. indet.* (1 in 60). A Sarcophagid has been seen on the flower of *A. leuconeura*, though the bore of the tube was too narrow to permit its entrance.

Muscidæ.

Lucilia sp. has been found in *A. gigas* only (51 in 1,325).

Stomatorrhina discolor F. was found in *A. ridicula*, but only one example in 2,546 flies.

Musca cingalaisina Big. was found in *A. ridicula :* as it was confused with another species the number is uncertain, but it was less than 35 in 2,546. *Musca lineata* Brun. occurred in *A. ringens* (3 in 136). *Chrysomyia megalocephala* Fb. (52 in 1,325) and *Chrysomyia ? combrea* Walk. (69 in 1,325) occurred in *A. gigas*.

Anthomyidæ.

Anthomyia bisetosa Thoms. (48 in 2,546) and a closely allied species occurred in *A. ridicula.*

Ophyra chalcogaster Wied. (3 in 1,325), and two other species of *Ophyra* (155 and 78 respectively in 1,325) were found in *A. gigas*. The second of these was also found in *A. ringens* (1 in 136), and in *A. sp. indet.* (7 in 60).

As will be evident from a later table, the *Anthomyidæ* provide the greatest number of species among the flies which visit *Aristolochia* flowers in Ceylon, but it has not been possible to obtain an identification of most of them. An Anthomyid is the principal visitor to *A. gigas* (794 in 1,325), and four undetermined species furnished 219 out of 2,546 flies in *A. ridicula.*

Borboridæ.

Limosina punctipennis Wd. was present in *A. ringens* to the number of 6 in 136.

Chloropidæ.

Hippelates ocellatus Lamb (124 in 2,546), *Hippelates nigricornis* Thoms. var. *bilineatus* Meij (9 in 2,546), and *Hippelates* *sp. indet.* (13 in 2,546) occurred in *A. ridicula.* The third of these was found in *A. leuconeura* (2 in 255), and the second in *A. ringens* (4 in 136). A single specimen of a *Hippelates* occurred in a collection of 294 flies from *A. floribunda.*

Cestoplectus intuens Lamb (41 in 2,546) and *Campsocera mutata* Beck (53 in 2,546) were found in *A. ridicula.*

A few examples of *Chlorops* sp., and one specimen of *Meromyza* sp. occurred among 294 flies from *A. floribunda,* and a single specimen of an undetermined genus of *Chloropidæ* in 258 flies from *A. fimbriata.*

Ephydridæ.

A single specimen of ? *Ilythea* sp. occurred among 258 flies from *A. fimbriata.*

Discomyza sp. was found in *A. leuconeura* (2 in 255) and *A. ringens* (2 in 136).

Drosophilidæ.

Two specimens of a species of *Drosophila* were found in 294 flies from *A. floribunda.* The same species constituted nearly the whole of a collection of 258 flies from *A. fimbriata,* together with one specimen of a second species of *Drosophila,* several specimens of a third, several specimens of a *Leucophenga,* and one specimen of *Phortica xyleboriphaga* White. *A. fimbriata* in Ceylon is evidently a Drosophilid flower.

Sapromyzidæ.

Lonchæa spp. are the principal visitors to *A. ridicula* in fine weather, 1,584 examples being taken in a collection of 2,546 flies. These included *Lonchæa aurea* Moq. and an undetermined species. *Lonchæa excisa* Kort (14 in 136) occurred in *A. ringens ;* and *Lonchæa bisulcata* Bez. (1 in 258) in *A. fimbriata.* Undetermined species occurred in *A. leuconeura* (2 in 255) and *A. gigas* (10 in 1,325).

Trypetidæ.

Chætodacus cucurbitæ Coq., 2 examples, and *Chætodacus ferruginea* F., one example, occurred among 2,546 flies from *A. ridicula.*

Acidia fossata Fb. is the principal visitor to *A. floribunda* at Peradeniya. That has been found to be the case on different occasions over a period of three years, and in two different localities. 220 examples occurred in a collection of 258 flies. All the specimens were males.

Ortalidæ.

Rivellia basilaris Wied. was found in *A. ringens* (26 in 136). *Plagiostenopterina ænea* F. occurred in *A. ringens* (3 in 136), and *A. sp. indet.* (2 in 60). *Chrysomyza ænea* F. occurred in *A. sp. indet* (2 in 60), and in *A. ringens* (4 in 136). *Euprosopia sp.* (2 in 136) was found in *A. ringens.*

Ortalidæ appear to be confined to the beaked *Aristolochia* flowers.

Phoridæ.

Species of *Aphiochæta* were found in seven of the species of *Aristolochia* examined. None of these has been determined. Two species occurred in *A. ridicula* (45 in 2,546); 123 examples out of 255 flies from *A. leuconeura ;* 502 examples out of 504 flies from *A. elegans ;* 4 examples out of 136 flies from *A. ringens ;* 2 examples out of 60 flies from *A. sp. indet. ;* several, representing two species, among 294 flies from *A. floribunda ;* and a single specimen of a species different from the last two, out of 258 flies from *A. fimbriata.*

Two specimens of an undetermined genus were found in *A. floribunda.*

In the case of *A. elegans* in Ceylon, *Aphiochæta* is practically the only visitor.

Bibionidæ.

Scatopse brunnescens (Brun.) occurred in *A. floribunda.*

Mycetophilidæ.

Sciara sp. occurred in *A. fimbriata* (3 in 258) and in *A. floribunda* (1 in 294).

Chironomidæ.

A *Chironomid* is the only species found in *A. indica* and *A. bracteata.* One specimen of *Ceratopogon* sp. occurred among 294 flies from *A. fimbriata.*

The following table gives a classification of the flies by families, that is, it shows the number of different species of each family which were found in the flowers named. This table is incomplete as, except in the case of *A. floribunda* and *A. fimbriata*, the classification was made from the residual material after specimens had been sent away for identification. Consequently, with few exceptions, it does not include species of which only one or two examples were present, but only those which were most numerous. These determinations were kindly made for me by Mr. R. Senior White.

	Ridicula.	Gigas.	Leuconeura.	Elegans.	Indica.	Ringens.	Sp. indet.	Floribunda.	Fimbriata.
Sarcophagidæ	3	1					1		
Muscidæ	2	3				1			
Anthomyidæ	15	7	1			1	6		
Borboridæ						1			
Chloropidæ	6		1			1	3	3	1
Ephydridæ									1
Drosophilidæ								1	5
Sapromyzidæ	2					1			1
Trypetidæ	2							1	
Ortalidæ						4	2		
Phoridæ	2		6	1			2	2	1
Bibionidæ								1	
Mycetophilidæ								1	1
Chironomidæ					1			1	

The *Anthomyidæ* provide the greatest number of species.

The Effectiveness of the Flowers.

The effectiveness of the flowers in attracting insects presumably depends upon their colour, form, and odour. Some estimate of it may be obtained by comparing the average number of insects found in the different flowers, though it has to be borne in mind that, in the present case, the figures do not in general relate to the flower in its native habitat. The averages given here were obtained from flowers gathered in the evening of their first day, between 4·30 and 6 P.M. It will be noted that the number of flowers is in some instances small; in the case of *A. sp. indet.* that is due to the fact that few flowers were available, but in *A. gigas* and *A. elegans* no further counts were made because it was evident from numerous other examinations that the number of insects was usually large.

The flowers examined may be divided into two series, those which have an appreciable odour, and those in which the odour is imperceptible. As already stated, the latter emit some odour which is perceived by insects, though not by man.

In the first series are—

A. gigas : flowers examined 10; average number of flies, 148.
A. leuconeura : flowers examined 63; average number of flies, 4·7.
A. sp. indet. : flowers examined 29; average number of flies, 3·9.
A. kewensis : flowers examined 28; average number of flies, 2·7.
A. ringens : flowers examined 60; average number of flies, 2.
A. floribunda : flowers examined 272; average number of flies, 1·1.

A. gigas, which takes first place, has certainly the most powerful odour, that of all the others being weak. *A. sp. indet.*, *A. kewensis*, and *A. ringens* are very similar in colour, with conspicuous external markings, while *A. leuconeura* is less brightly coloured, and uniformly purple-brown or liver coloured externally. The last named is a somewhat inconspicuous flower, but its colour may be more attractive than that of the more conspicuous *A. ringens.*

In the second series are—

A. elegans : flowers examined 10; average number of flies, 53.
A. ridicula : flowers examined 504; average number of flies, 5·4.
A. fimbriata : flowers examined 51; average number of flies, 5·2.
A. indica : flowers examined 91; average number of flies, 0·3.

Of these, *A. indica* is the least conspicuous and its colour is dull: but, as previously stated, its low average may be due to its situation in an unnatural locality.

The most striking feature of the two series is that, in both, the hooded type of flower is the most effective. The bizarre forms, *A. ringens*, &c., and *A. ridicula*, attract few flies in comparison. As the hooded type would appear to be the more primitive, the advantage of a further evolution in the direction taken by these extraordinary forms is not obvious.

A. elegans, in which the peculiar Aristolochia adaptations are the most imperfect, produces the greatest number of fruits.

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EXPLANATION OF PLATES.

Plate I.

Fig. 1.—*A. ridicula*, unopened flower ; natural size.

Fig. 2.—*A. ridicula*, expanded flower, first day ; natural size.

Fig. 3.—*A. ridicula*, face of the flower, first day ; natural size ; the opening is represented too dark in order to show the white hairs.

Fig. 4.—*A. ridicula*, longitudinal section of the flower ; natural size.

Fig. 5.—*A. ridicula*, the inner end of the tube as seen from the bulb, with an irregularly thickened zone above, and a darker food area above that ; natural size.

Fig. 6.—*A. ridicula*, a hinged hair ; × 10.

Fig. 7.—*A. ridicula*, the gynostegium, first day ; × 4.

Fig. 8.—*A. ridicula*, apex of bulb, viewed from the interior after removal of the gynostegium, showing the window area ; natural size.

Fig. 9.—*A. ridicula*, apex of bulb (half cut away), showing the window area, and the gynostegium on the second day, after dehiscence of the anthers ; natural size.

Fig. 10.—*A. indica*, first day position ; natural size.

Fig. 11.—*A. indica*, longitudinal section ; natural size.

Fig. 12.—*A. indica*, second day position of the flower ; natural size.

Fig. 13.—*A. indica*, wall of the bulb above the inner end of the tube, viewed from within the bulb, showing the two dark food areas, situated on white patches ; × 2.

Fig. 14—*A. indica*, gynostegium, first day ; × 6.

Fig. 15.—*A. indica*, gynostegium, second day ; × 6.

Fig. 16.—*A. ridicula*, the face on the second day, details omitted ; natural size.

Plate II.

Fig. 1.—*A. gigas*, unopened flower ; × $\frac{1}{4}$.

Fig. 2.—*A. gigas*, apex of bulb ; natural size.

Fig. 3.—*A. gigas*, cross section of bulb ; × $\frac{1}{2}$.

Fig. 4.—*A. gigas*, young flower, natural size.

Fig. 5.—*A. gigas*, longitudinal section of flower, the greater part of the outer hood cut away, and the hairs omitted ; × $\frac{1}{4}$.

Fig. 6.—*A. elegans*, longitudinal section ; natural size.

Fig. 7.—*A. elegans*, inner opening of tube, viewed from the bulb, showing the two dark food areas above the white thickened zone ; natural size.

Fig. 8.—*A. leuconeura*, first day position of flower ; natural size.

Fig. 9.—*A. leuconeura*, inner end of tube, viewed from the bulb ; natural size.

Plate III.

Fig. 1.—*A. leuconeura*, second day position ; natural size.

Fig. 2.—*A. leuconeura*, face of the flower ; natural size.

Fig. 3.—*A. leuconeura*, longitudinal section of flower in second day position ; natural size.

Fig. 4.—*A. leuconeura*, gynostegium, first day ; × 4.

Fig. 5.—*A. leuconeura*, gynostegium, second day ; × 4.

Fig. 6.—*A. floribunda*, face of flower ; natural size.

Fig. 7.—*A. floribunda*, lateral view of flower ; natural size.

Fig. 8.—*A. floribunda*, longitudinal section of flower, hairs omitted ; natural size.

Fig. 9.—*A. floribunda*, inner end of tube, viewed from the bulb, with food areas above the thickened zone ; natural size.

Plate IV.

Fig. 1.—*A. ringens*, expanded flower, first morning ; × $\frac{1}{2}$.

Fig. 2.—*A. ringens*, inner end of tube, viewed from the bulb, showing white food areas ; natural size.

Fig. 3.—*A. ringens*, cross section of the beak ; natural size.

Fig. 4.—*A. ringens*, a young flower ; natural size.

Fig. 5.—*A. kewensis*, a young unopened flower ; the division into beak and standard is indicated by the deep sinus on the lower edge ; × $\frac{1}{2}$.

Fig. 6.—*A. sp. indet.*, expanded flower, first morning ; × $\frac{1}{2}$.

Fig. 7.—*A. tricaudata*, the hood and appendages removed ; natural size.

Fig. 8.—*A. tricaudata*, section of Fig. 7, the front of the tube removed ; (*a*) teeth descending from the lip ; (*b*) passage from exterior ; (*c*) lateral plate ; (*d*) passage to the bulb ; natural size.

Fig. 9.—*A. tricaudata*, longitudinal transverse section, showing the lip viewed from behind, with two descending teeth, and the ends of the lateral plates projecting into the cavity below the lip ; natural size.

Plate V.

Fig. 1.—*A. fimbriata*, first day ; natural size.

Fig. 2.—*A. fimbriata*, longitudinal section, second day ; natural size.

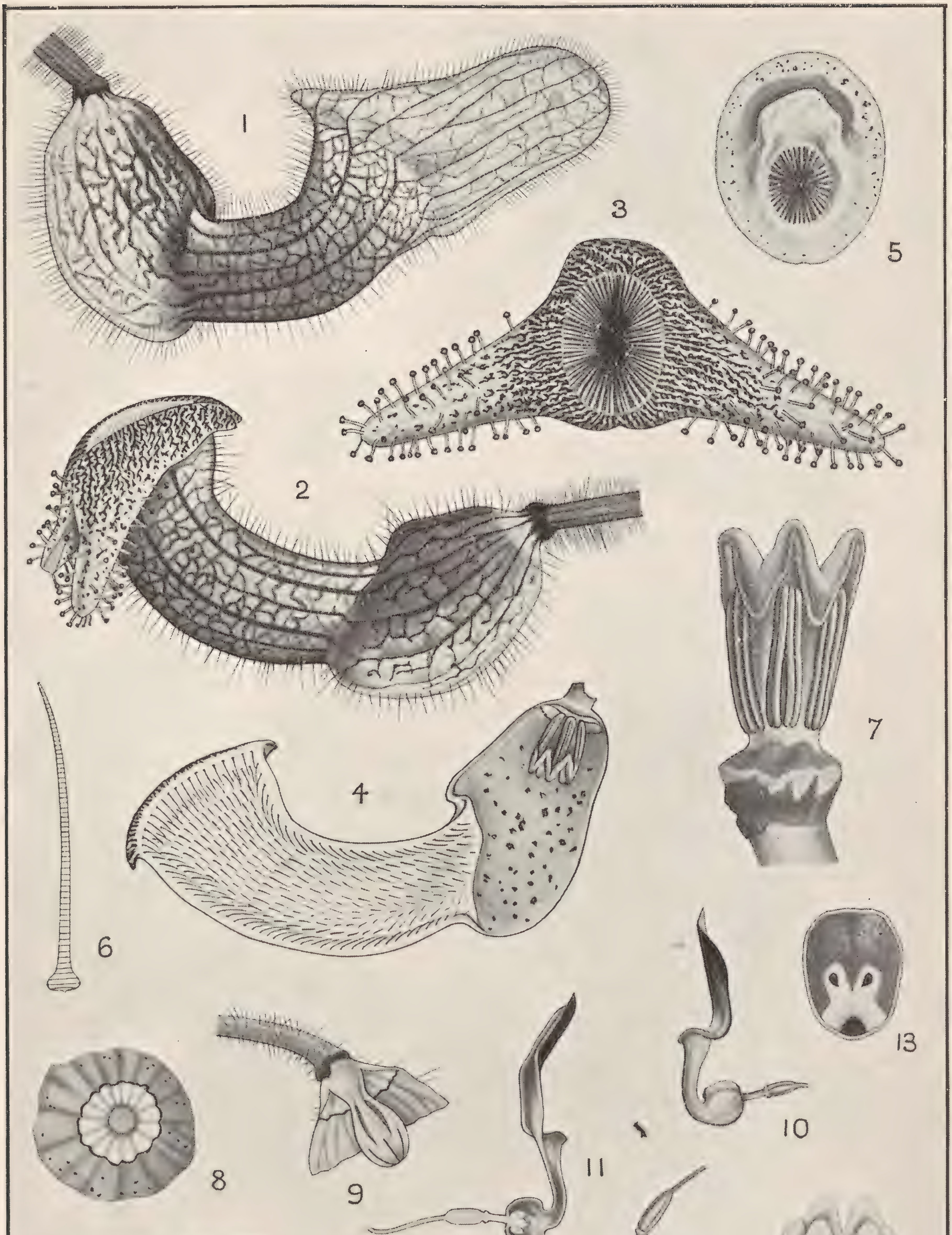
Fig. 3.—*A. tricaudata*, unopened flower ; natural size.

Fig. 4.—*A. tricaudata*, expanded flower after the appendages have fallen to a vertical position ; × $\frac{2}{3}$.

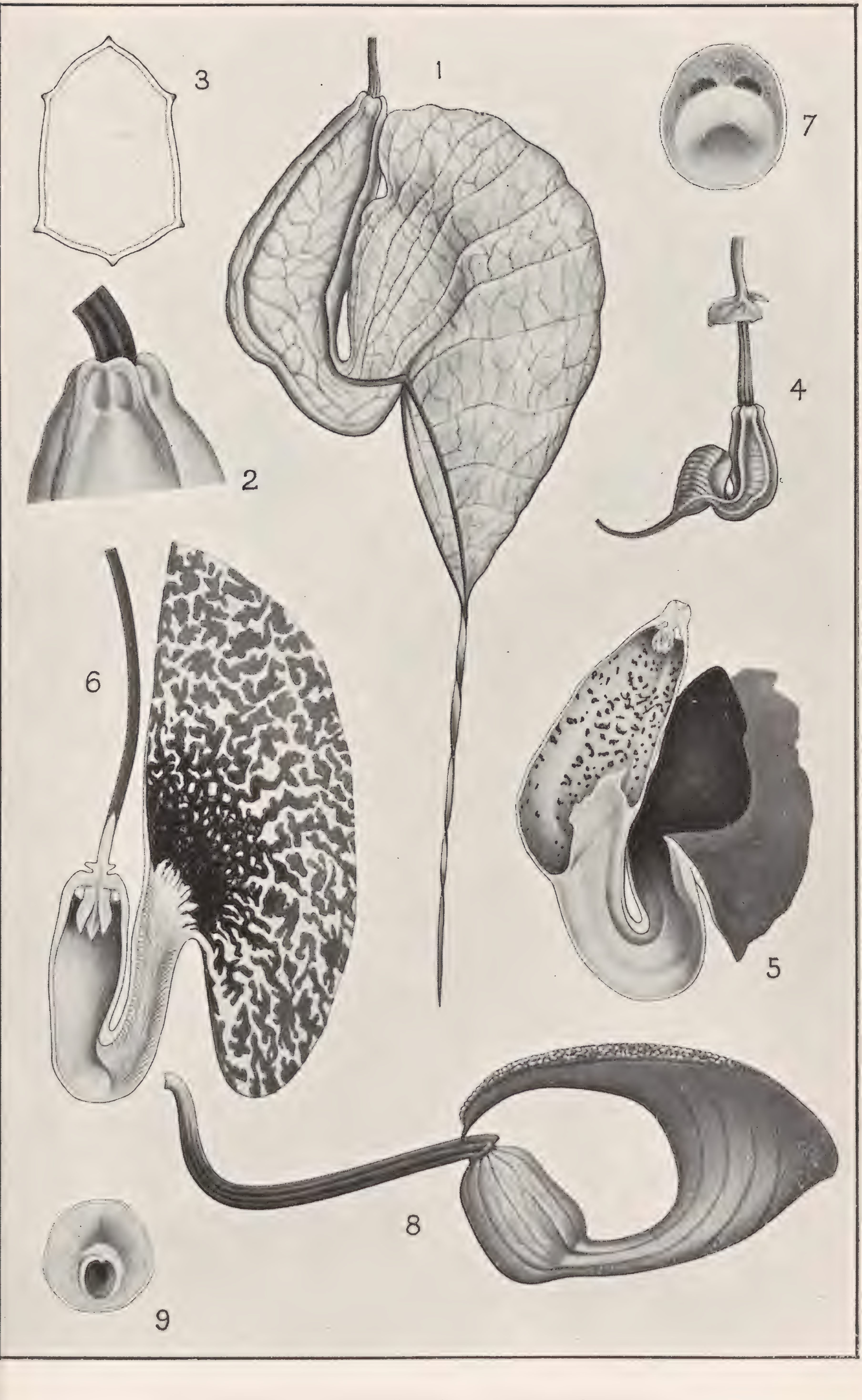
Fig. 5.—*A. tricaudata*, median longitudinal section, hood and appendages omitted, showing concrescence of the tube and bulb, a lateral plate, and a tooth on the lip ; natural size.

Fig. 6.—*A. tricaudata*, an abnormal (?) lip ; natural size.

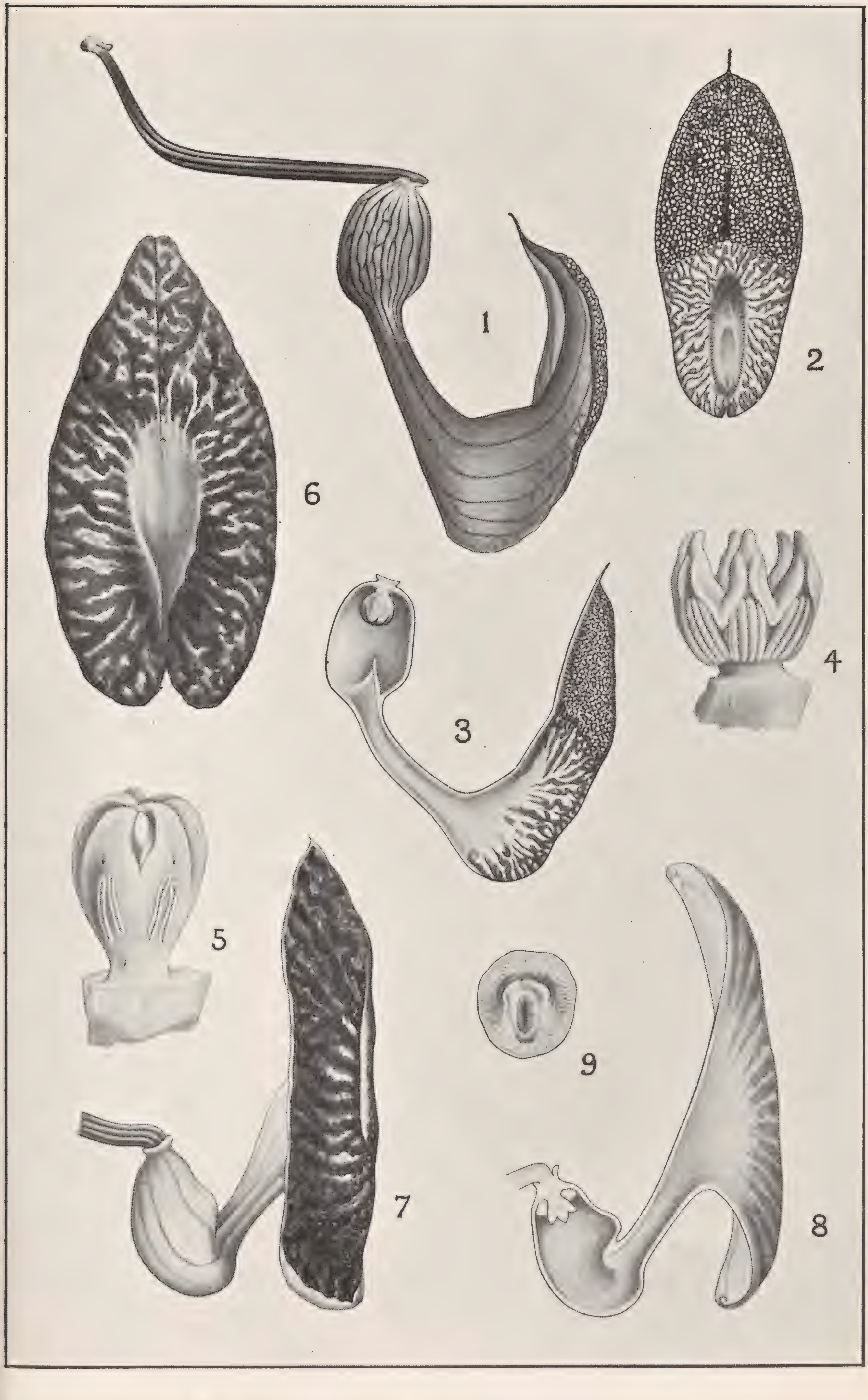
Fig. 7.—*A. tricaudata*, gynostegium, before dehiscence of the anthers : × 4.



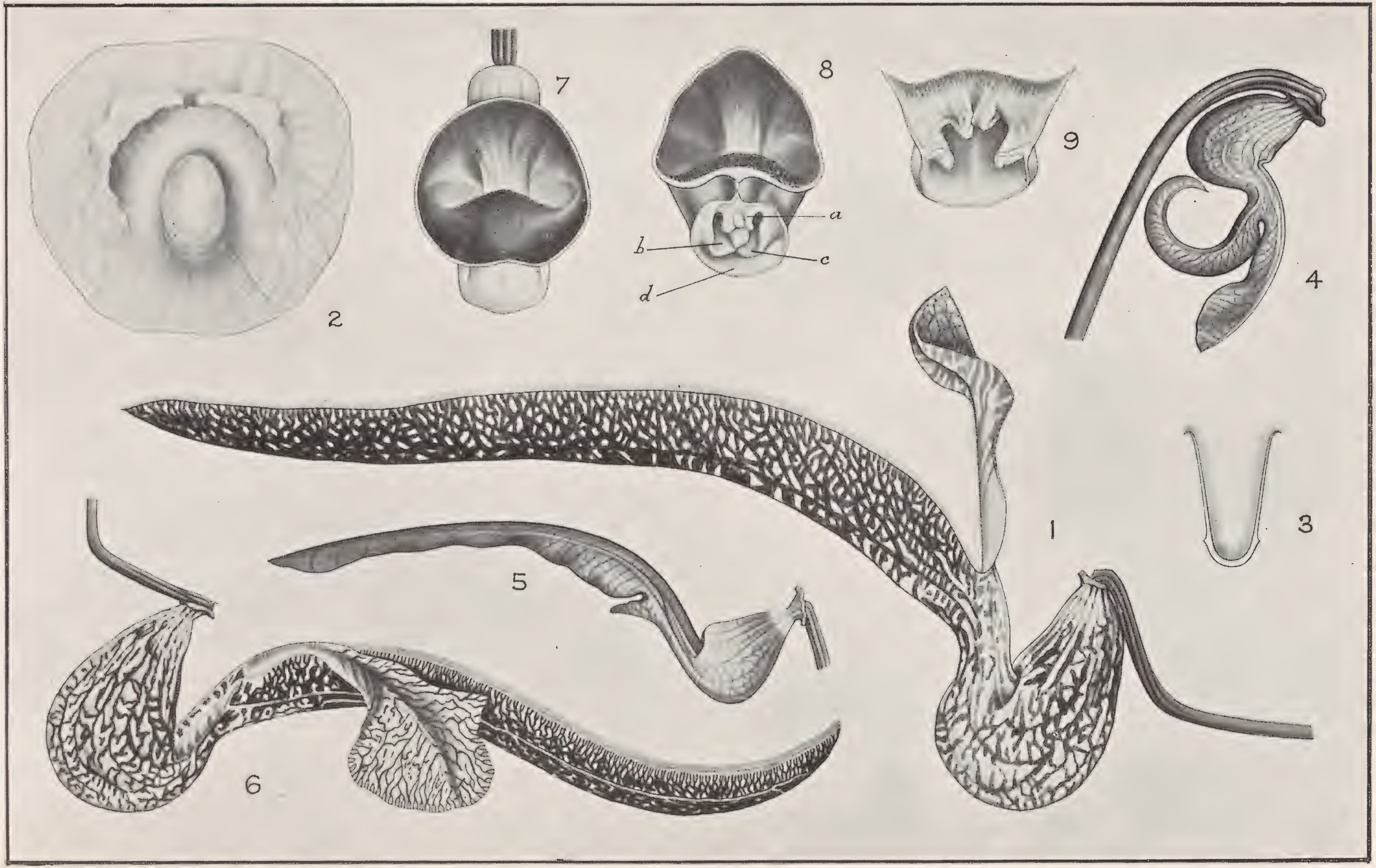
A. RIDICULA, A. INDICA.



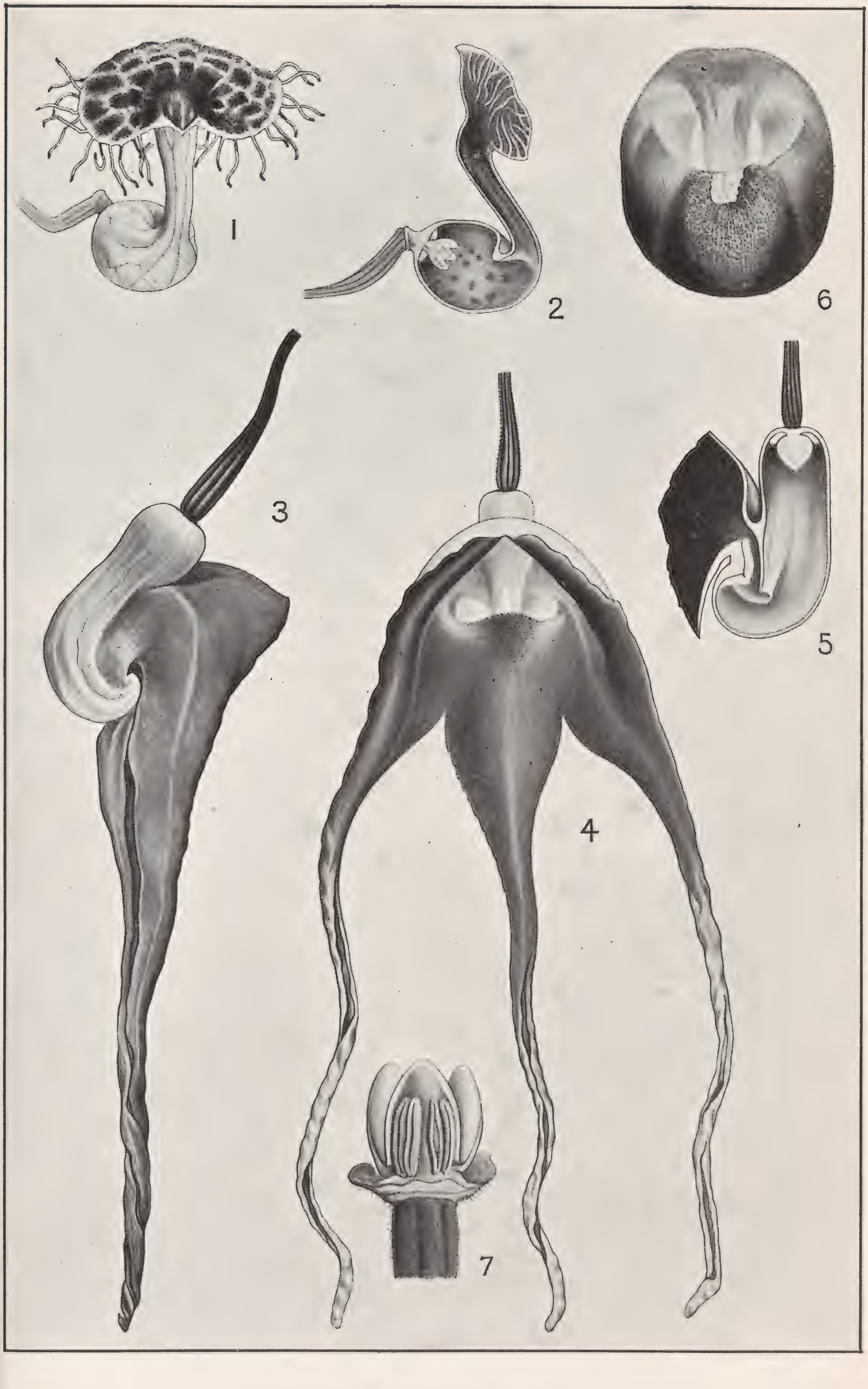
A. GIGAS, A. ELEGANS, A. LEUCONEURA.



A. LEUCONEURA, A. FLORIBUNDA.



A. RINGENS, A. KEWENSIS, A. TRICAUDATA.



A. FIMBRIATA, A. TRICAUDATA.

The Occurrence of Teleutospores in Hemileia vastatrix B. & Br.

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The teleutospores of *Hemileia vastatrix* were described by Marshall Ward in his Reports on the Coffee Leaf Disease, and his papers on the life history and morphology of that fungus. Subsequent investigators of this disease have, however, failed to find teleutospores. Zimmermann (5) recorded that he did not find them in Java. Butler (1) states that "Teleutospores have been discovered in Ceylon, but they appear to be rarely produced, and have not been encountered in other countries, except in the form on a wild species of coffee in German East Africa," and Dowson (2) remarks that "the first observation of importance is that only once in Africa and in Ceylon have the teleutospores of the parasite been found. It is a curious and as yet an unexplained fact that since Marshall Ward worked out the life history of the fungus in Ceylon, and a German observer reported the presence of teleutospores on some African specimens of the disease not long afterwards, these spores have never been observed since."

The extra-Ceylon occurrence referred to by Butler and Dowson would appear to be that recorded by Massee in an article on Coffee Disease in East Africa in the Kew Bulletin, 1913, pp. 168–171. Massee examined a specimen from the Berlin Herbarium which had been assigned to *Hemileia Woodii* and was said to be on *Coffea Ibo.* It had been collected by Perrot in German East Africa. This specimen contained teleutospores. Massee decided that the fungus was not *Hemileia Woodii*, but *Hemileia vastatrix*, and stated that the host plant did not agree with any species of *Coffea* in the Kew Herbarium. The latter statement would seem to indicate some doubt whether the host plant was really a *Coffea*, but Massee's further remarks in the same article clearly demonstrate that he regarded it as belonging to that genus.

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Marshall Ward's papers do not show that he found the teleutospores rare in Ceylon. After recording the first observation of them on March 22, 1880, he stated " associated with the same external features, I have since re-discovered these bodies at various places and times, *e.g.*, Maturata (March 25), Ambagamuwa (April 5), Peradeniya (May and June)." That was in his first Report (3), written in June, 1880, after four months' investigation. In his second Report (4), written in December, 1880, he stated that the smooth turnip-shaped spores (*i.e.*, the teleutospores) were far commoner than he had at first supposed.

In order to obtain further information concerning the occurrence of teleutospores in Ceylon, periodic observations of leaves of coffee attacked by *Hemileia* were begun by the writer, at the suggestion of Mr. T. Petch, Government Botanist and Mycologist, in May, 1921, and continued until April, 1922. These were carried out at Peradeniya on coffee in three localities at first, viz., on the Experiment Station, on New Peradeniya Estate, and in the grounds of the Agricultural School, but the trees in the last-named locality were felled after a few months. The species of *Coffea* examined were *Coffea arabica*, *Coffea liberica*, and *Coffea robusta.* On each visit, from twenty-five to fifty leaves were gathered, all in an advanced stage of the disease, and taken to the laboratory, where they were examined microscopically for teleutospores. Forty-four observations were made, the results of which are summarized in the Table I. Table II. gives the daily rainfall in inches for the period, the dates on which teleutospores were observed being indicated by an asterisk.

The weather previous to the period of observation was as follows :—No rain fell during February, 1921. In March the total rainfall was 1·15 inches. In April it was 5·73 inches on twenty-two days. The average rainfall at Peradeniya for these three months is 1·57, 4·67, and 9·66 inches respectively. The rainfall for these months in 1921 was therefore below the average.

In May, coffee on the New Peradeniya Estate was quite free from leaf disease, with the exception of two bushes which were slightly attacked. The coffee on this estate consists of a single row of *Coffea arabica* planted along the roadsides and, in general, beneath large roadside shade trees (*Pithecolobium Saman*). The two affected bushes, however, were in the open by the side of a road which is not shaded. On the Experiment Station, Peradeniya, where most of the coffee is planted in blocks under shade, all the bushes were free from leaf disease, except a few isolated unshaded bushes of *Coffea robusta*. Teleutospores were found on *Coffea arabica* on New Peradeniya, but not on the diseased *Coffea robusta* on the Experiment Station. The rainfall for this month was 1·69 inches, as against an average of 7·16 inches. The range of temperature was 68·5–93·4 F. In both localities, the bushes attacked by leaf disease were unshaded.

In June the rainfall was 4·63 inches (average, 10·17 inches). The range of temperature was 70·2–89·9 F. Leaf disease was general in all three localities. Teleutospores were found at each examination, on *Coffea robusta* in the early part of the month, and on *Coffea arabica* later.

In July the rainfall was 6·87 inches (average 6·84), chiefly during the last twelve days. The range of temperature was 68·5–92·5 F. Badly diseased leaves began to fall from about the middle of the month, and by the end of the month all the affected bushes were almost bare of foliage. This was especially the case on an unshaded plot of *Coffea* sp. (aff. *robusta*) on the Experiment Station. Teleutospores were found at all examinations, once on *Coffea liberica* and twice on *Coffea arabica*. The leaf disease was more prominent on the bushes at New Peradeniya Estate than at the Experiment Station during the last two months.

In August the rainfall was 11·87 inches (average 5·96) on twenty-four days. The range of temperature was 61–83·3 F. No teleutospores were found in the four observations made, thrice on *Coffea arabica* and once on *Coffea robusta*. By the first week of this month all the affected bushes were putting out new foliage.

In September the rainfall was 2·19 inches (average 6·40), chiefly during the first week. The range of temperature was 69·3–85·6 F. The disease was in an early stage with rare advanced cases. Teleutospores were observed twice on the leaves of *Coffea arabica*, once at the Experiment Station and once at New Peradeniya Estate.

In October the rainfall was 10·50 inches (average 13·18), with a break in the middle of the month. The range of temperature was 66–87·5 F. The disease did not progress during this month. No teleutospores were found, although five observations were made, twice on *Coffea arabica* at New Peradeniya Estate and three times on *Coffea robusta* at the Experiment Station.

In November the rainfall was 2·82 inches (average 9·74), chiefly during the first week. The range of temperature was 66–84·5 F. The nights were cool and misty with bright sunshine from the 10th to the end of the month. Teleutospores were found on two occasions, once on *Coffea robusta* at the Experiment Station and once on *Coffea arabica* at the New Peradeniya Estate. By the end of this month the disease was very common in both localities.

In December the rainfall was 6·06 inches (average 8·07), with intervening bright sunshine. The range of temperature was 65·7–82·9 F., with misty cool nights. By the end of this month the disease had well set in. Teleutospores were observed on four occasions, twice on *Coffea robusta* and twice on *Coffea arabica.*

In January, 1922, the rainfall was 1·21 inches (average 2·83), chiefly between the 4th and 10th. The days were bright with misty cool nights. The range of temperature was 61·3–84·3 F. Teleutospores were found on four occasions, three times on *Coffea arabica* and once on *Coffea robusta.* By the latter part of this month there was not a single leaf free of disease on the affected bushes. At this season the disease was equally severe in both the localities. The *arabica* plot at the Experiment Station was very badly affected as compared with the *robusta* plot.

In February the rainfall was 5·25 inches, against an average of 1·57 inches. The days were warm with misty cool nights. Teleutospores were found on four occasions, three times on *Coffea arabica* and once on *Coffea robusta.*

March had a low rainfall of 2·48 inches, against an average of 4·67, with bright sunshine. The range of temperature was

66·9–91·4 F. Teleutospores were observed on four occasions, three times on *Coffea robusta* and once on *Coffea arabica.* The affected trees began to shed their leaves from the early part of this month, and by the end all the trees were bare of foliage in both the localities.

During the last four months the disease was severe, and teleutospores were frequently observed.

In April the rainfall was 6·84 inches (average 9·65). The range of temperature was 69–95 F. The affected trees were putting out new foliage. No teleutospores were found.

Summary of Observations.

The rainfall in March, April, May, 1921, was much below the average, and the leaf disease was present only on a few exposed bushes in the latter month. In June, although the rainfall was still below the average, leaf disease became general, and it increased until the middle of July, when the affected bushes began to shed their leaves. By the end of July the bushes were almost completely defoliated.

In August the rainfall was about twice the normal. The bushes were then putting out new foliage. In September the rainfall was again deficient, but the disease was nevertheless re-appearing. It did not make much progress in October, when the usual heavy rainfall occurred, but was general in November, December, and in January and February, 1922. At the beginning of March, 1922, the affected bushes began to shed their leaves and were bare at the end of the month, new foliage developing in April.

The disease may be said to have occurred in two distinct periods—a short attack in June–July, culminating in general defoliation at the end of July, and a prolonged attack from September to February, with defoliation in March.

It is probable that the heavy rains of October hindered the dissemination of the spores, and so retarded the progress of the disease, while the low rainfall of November was again unfavourable, so that general infection did not occur until December. This would account for the retardation of the most severe phase of the disease until January, 1922. The temperature during September–January is lower than during May–July, but the difference would appear to be insufficient to account for the marked difference in the duration of the disease.

Teleutospores were found in every month, except August and October, 1921, and April, 1922. Those found in May, 1921, were probably the result of an infection in the previous month or earlier. None were found in August, as the bushes were then developing new foliage, but they were found on two occasions in September on old diseased leaves, probably persistent from the previous July. They were not found in October, though the disease was then general, but occurred in every subsequent month until the following April, when the bushes again put out new leaves.

It would appear that from an attack beginning in May, teleutospores occurred in June–July, while from the attack which began in September they occurred from November onwards.

Observations were not sufficiently continuous to enable any deductions to be made concerning the relation of the appearance of teleutospores to the breaks which occurred in the rains. On the present evidence, it can only be said that the teleutospores occur when the leaves are badly attacked and the uredo sori are in an advanced stage.

The Teleutospores.

Observations were made of the germination of the teleutospores in water and 1 per cent. cane sugar solution. The promycelium is longer in the latter. In water the promycelium becomes septate in less than eighteen hours. The promycelium is usually three-septate, but four septa have been seen in a few instances. The promycelium in water culture measures 125–195 × 8–10μ after fourteen to sixteen hours, while in sugar solution it measures 105–220 × 8–9μ after fourteen to twenty-four hours. Promycelia developed in nature in the sorus on the coffee leaf measure 65–80 × 8–10μ.

Marshall Ward figures a three-septate promycelium, but mentions four-septate promycelia in his description. The promycelium in nature is stouter and shorter than those in culture. The sterigmata obtained in culture are longer than those observed on the promycelium on the leaf. On two occasions I found the sporidia germinate while still attached to the promycelium.

A single teleutospore was observed in *Hemileia Canthii* B. & Br. on *Canthium campanulatum* on February 1, 1922. This had produced a promycelium in the sorus. The teleutospore was much smaller, and the promycelium more slender and brighter in colour than in *Hemileia vastatrix.*

My thanks are due to Mr. T. Petch, Government Botanist and Mycologist, for assistance during this investigation and in the preparation of this paper.

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Table I.

Dates of Observation.	Occurrence of Teleutospores.	Locality.	Species of Coffee.
May 20, 1921	+	N. P.	arabica
May 28, 1921	—	E. S. P.	robusta
June 10, 1921	+	E. S. P.	robusta
June 15, 1921	+	N. P.	arabica
June 21, 1921	+	N. P.	arabica
June 28, 1921	+	N. P.	arabica
July 1, 1921	+	N. P.	arabica
July 8, 1921	+	I. E.	liberica
July 18, 1921	+	N. P.	arabica
August	—	(3) N. P.	arabica
(4 occasions)	—	(1) E. S. P.	robusta
September 2, 1921	+	N. P.	arabica*
September 20, 1921	+	E. S. P.	arabica*
September 27, 1921	—	I. E.	liberica
October 3, 1921	—	N. P.	arabica
October 10, 1921	—	E. S. P.	robusta
October 14, 1921	—	N. P.	arabica
October 17, 1921	—	E. S. P.	robusta sp. (Aff:)
October 21, 1921	—	E. S. P.	robusta
November 1, 1921	+	E. S. P.	robusta
November 10, 1921	—	N. P.	arabica
November 21, 1921	—	E. S. P.	robusta
November 27, 1921	+	N. P.	arabica
December 3, 1921	+	N. P.	arabica
December 12, 1921	+	N. P.	arabica
December 16, 1921	+	E. S. P.	robusta & arabica
December 20, 1921	+	E. S. P.	robusta
January 5, 1922	+	E. S. P.	robusta
January 10, 1922	+	N. P.	arabica
January 20, 1922	+	N. P.	arabica
January 23, 1922	—	E. S. P.	robusta
January 31, 1922	+	N. P.	arabica
February 8, 1922	+	N. P.	arabica
February 14, 1922	+	N. P.	arabica
February 21, 1922	+	E. S. P.	robusta
February 27, 1922	+	N. P.	arabica
March 2, 1922	+	E. S. P.	robusta
March 6, 1922	+	E. S. P.	robusta†
March 15, 1922	+	N. P.	arabica†
March 29, 1922	+	E. S. P.	robusta
April 3, 1922	—	N. P.	arabica
April 5, 1922	—	N. P.	arabica
April 11, 1922	—	E. S. P.	robusta

N. P. = New Peradeniya.
E. S. P. = Experiment Station, Peradeniya.
I. E. = Irene Estate, (School of Tropical Agriculture.)

* On old leaves. † Fallen leaves.

Table II.

Daily Rainfall in Inches.

	1921.								1922.			
Date.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.
1	·41	—	—*	·82	·03	—	—*	·92	—	—	—	—
2	—	·18	—	·60	·35*	—	·11	·10	—	—	—*	—
3	—	·08	—	·90	·47	·28	·77	—*	—	2·31	—	—
4	—	1·36	·23	1·02	—	·19	·14	—	·38	·23	·30	—
5	·06	·23	—	·45	—	—	·03	—	—*	·58	—	—
6	·21	·07	·19	·32	·05	·86	·51	—	·52	—	—*	·21
7	—	·12	·24	1·00	·32	·02	·84	—	·06	—	—	·64
8	—	1·38	·15*	—	·06	—	—	—	·10	—*	—	—
9	·06	·07	·06	·10	·34	—	—	·47	—	—	—	—
10	—	—*	—	·05	—	·70	—	·28	—*	—	·44	—
11	—	·14	—	·32	—	·13	—	—	·15	—	—	—
12	—	—	—	·45	—	—	—	—*	—	1·03	—	—
13	—	—	—	—	—	—	—	—	—	·38	—	·08
14	·07	—	·15	—	—	—	—	—	—	—*	—	—
15	·08	—*	—	—	—	—	—	—	—	—	—*	—
16	·05	—	—	·09	—	—	—	—*	—	—	—	·95
17	—	—	—	·12	—	—	—	—	—	—	—	—
18	—	—	—*	—	—	—	—	—	—	—	—	2·01
19	—	·11	—	·34	—	·93	—	·39	—	—	—	1·30
20	—*	·54	·08	·25	—*	1·13	·42	·05*	—*	—	—	1·39
21	—	·10*	·16	·03	—	·71	—	—	—	—*	·88	·26
22	—	—	·09	·06	—	—	—	—	—	—	·86	—
23	—	—	·50	—	—	·97	—	—	—	—	—	—
24	—	·03	·63	—	—	·24	—	—	—	—	—	—
25	—	·06	·22	·05	—	1·80	—	—	—	—	—	—
26	·75	—	·45	1·05	—	·43	—	—	—	·72	—	—
27	—	·25	·49	1·07	—	·23	—*	1·87	—	—*	—	—
28	—	·08*	·40	2·46	·60	·44	—	1·95	—	—	—	—
29	—	·03	·80	·30	—	—	—	—	—	—	—*	—
30	—	—	·65	·01	—	1·37	—	·95	—	—	—	—
31	—	—	·38	·53	—	·07	—	—	—*	—	—	—
Tota	1·69	4·83	6·87	11·87	2·19	10·50	2·82	6·06	1·21	5·25	2·48	6·84

* Shows the dates on which teleutospores were found.

Xylariaceæ Zeylanicæ.

BY

T. PETCH, B.A., B.SC.

The following account deals with the *Xylariaceæ* which have been recorded for Ceylon up to the present date, including those enumerated by Berkeley and Broome in the *Fungi of Ceylon*, &c., and by Cesati in *Mycetum in itinere Borneensi a cl. Beccari lectorum enumeratio*, and others recently collected.

Xylaria.

Xylaria digitata Grev.—The Ceylon specimens in Herb. Kew are (*a*) Thwaites 31, very immature specimens; (*b*) Thwaites 1112, which are immature *Xylaria nigripes;* (*c*) Thwaites 582, immature *Xylaria allantoidea*, marked *X. digitata f. minor;* (*d*) Thwaites 583, marked "? diseased state of 582," and (*e*) Thwaites 580, marked " dubia " : the last are large, clavate specimens, with long or short stalks. Herb. Peradeniya has (*b*) Thwaites 1112, immature *Xylaria nigripes*, and (*e*) Thwaites 580; of the latter there is one specimen, simple, clavate, 8 cm. high, 1·2 cm. diameter, hollow, immature. It is possible that (*e*) is an immature example of *X. allantoidea.* There are no specimens which could be assigned with any degree of certainty to *X. digitata.*

Xylaria tabacina Kickx.—Berkeley and Broome recorded *Xylaria tabacina* Kickx in Fungi of Ceylon, No. 1033, from Thwaites 643 in part, and *Xylaria involuta* Kl., in Fungi of Ceylon, No. 1032. They gave the spores of the former as 10 × 5 μ. According to Cooke (Grevillea, XI., p. 82), *Xylaria involuta* is the same as *Xylaria tabacina*, and its spores measure 22–25 μ. Bresadola is of the same opinion (Ann. Myc., V., p. 241), and gives the spores as 20–23 × 7 μ. Lloyd (Xylaria Notes, No. 1) details the history of the two names and shows that *Xylaria tabacina* is to be adopted; he gives the measurement of the spores as 20–24 × 6–8 μ.

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In the cover of *Xylaria tabacina* in Herb. Kew are sheets (*a*) bearing one specimen marked "*Xylaria involuta* Kl. Ceylon, G.H.K.T., 4–5,000 ft., 1867"; (*b*) no specimens, but apparently originally bore four, labelled "*Xylaria involuta* Ceylon, G.H.K.T."; (*c*) Thwaites 643, one specimen and a drawing of a spore, marked "0·0004–0·0002." The last-named is the specimen referred to *X. tabacina* (643 in part) in Fungi of Ceylon, No. 1033.

In Herb. Peradeniya there is one sheet bearing seven halves, or parts, of four or five specimens, Thwaites 643.

The specimen of *Xylaria tabacina*, Thwaites 643, in Herb. Kew, has spores, 18–24 × 6–8 μ. The corresponding specimen in Herb. Peradeniya is immature, but appears to be *Xylaria zeylanica.* The remainder of Thwaites 643 in Herb. Peradeniya are *Xylaria exalbata*, and have spores, 7–9 × 4–5 μ. The latter species was separated from Thwaites 643 by Berkeley and Broome, but they attached its spore measurement to *Xylaria tabacina. Xylaria tabacina* appears to be rare in Ceylon: I have no recent collection.

Xylaria exalbata B. & Br.—This was Thwaites 643 in part. The specimens in Herb. Peradeniya vary from 2·5 to 8 cm. in height. The stalk of the smallest specimen is 5 mm. long, that of the largest 4 cm. long. The stalks are glabrous, 2·5–4 mm. diameter, equal; the head is clavate, expanding uniformly from the stalk. The head is described by Berkeley and Broome as white, and it is covered with a thin, white pellicle in the dried specimens, but it may have been purple-grey when fresh. The ostiola are black, projecting, obtusely conical, scattered on mature specimens, but appearing crowded on immature examples. Among the specimens in Herb. Kew, one is densely tomentose at the base; this may be a different species, but it is apparently immature. Cooke gave the spores of *X. exalbata* as 12 × 3 μ; my measurements are 7–9 × 4–5 μ, oval, or subcymbiform, black-brown. The perithecia are comparatively small. In spores and perithecia, this species resembles *X. allantoidea*, from which it differs in its glabrous, white, outer layer, and, in general, in its longer stalk and clavate head. It does not resemble *X. grammica*, as suggested by Theissen.

Xylaria allantoidea Berk.—This formed Thwaites 1113. There are Ceylon specimens in Herb. Kew, and Herb. Peradeniya. The spores in these are black-brown, oval, 7–9 × 3·5–4 μ. This is the general average of Ceylon specimens, the dimensions being slightly less than those given by Lloyd (14 × 6 μ). In one Peradeniya gathering (No. 3327) they measure 9–12 × 4–5 μ. The conidial stage of this species is *Isaria flabelliformis*, as far as relates to the record of the latter for Ceylon. The immature perithecial clubs are at first covered with a very thin coat of matted hyphæ, which cracks into areolæ and weathers off. In some gatherings, the stromata are globose, or flattened globose, centrally attached, without any evident stalk. In general, they are cylindric, or elongated ovate, contracted rather abruptly below into a short stout stalk. When old they become hollow. As in the commoner forms of *Xylaria nigripes*, the perithecial stage does not, as a rule, develop from the conidial stage.

Xylaria zeylanica Berk.—This species was collected by Gardner, and described by Berkeley in Hooker's London Journal of Botany, VI., p. 513 (*sub Sphæria*). The type in Herb. Kew contains fragments of one specimen only. They are black, with a very slight rusty pruina, brittle, up to 1 mm. thick, even, with slightly projecting ostiola. Berkeley stated that the spores were minute, elliptic ; Cooke (Grevillea, XI., p. 82) gave them as 18 × 3·5 μ, which, it may be noted, is the measurement of the spores in some of the fragments of *Xylaria Thwaitesii*. The fragments of *Xylaria zeylanica* resemble Ceylon specimens of *Xylaria allantoidea*, but the spores measure 11–15 × 4–6 μ, and are broadly cymbiform to oval. The spores are thus larger than the average of *Xylaria allantoidea* in Ceylon. Berkeley's description (*ex* Saccardo) is "Suberosa ; clavulis lanceolatis, compressis, lævibus, atrolaccatis, cum stipitibus rugosis, brevibus confluentibus ; ostiolis minutissimis ; sporidiis ellipticis minutis. 3–4 cent. alta, ostiolis granulat nigra, pruina ferruginea conspersa." From the specimen, it was evidently hollow, carbonaceous, and brittle, with fairly prominent ostiola.

In recent examples, which I take to be this species, the stalk is black or blackish-brown, glabrous, and the clava when immature is pale brown with a matt surface formed by a thin layer of interwoven hyphæ. Mature examples are clavate or subcylindric, with an ill-defined stout, ridged or lacunose stalk. The stalk, as a rule, is not more than one or two centimetres long, and about the same diameter, and in the majority of specimens the club is terete, about 3 cms. diameter and 12 cm. long, but strongly curved. The stalks are sometimes connate at the base. One specimen is subcylindric, 17 cm. high and 3–4 cm. diameter, while another has an ovate, compressed clava, 10 cm. long, 6 cm. wide, and 3 cm. thick, and a stalk 5 cm. high, expanding upwards to a breadth of 2 cm. The mature clava is purple-grey, with a thin outer hyphal coat which is minutely cracked, usually longitudinally. This coat appears to have weathered off from the type specimen. The club becomes hollow, and sometimes splits on either side down the middle. The spores in these recent specimens are cymbiform to narrow-oval, 13–16 × 5 μ, exceptionally 6 μ broad, in one collection, and 12–15 × 5–6 μ in another.

Xylaria Thwaitesii Berk. & Cke.—This was described by Cooke in Grevillea, XII., p. 1, from specimens in Berkeley's herbarium. The spores were said to be fusiform, straight or curved, 15–18 × 5 μ, and Cooke stated that it was allied to *X. fistulosa* Lév., but externally quite smooth. The type in Herb. Kew is a mixture of fragments. Some pieces have slightly-projecting ostiola, and spores 7–9 × 4 μ, and do not differ from Ceylon specimens of *X. allantoidea.* The other pieces have spores, 15–18 × 6–7 μ, cymbiform, straight or slightly curved. The latter pieces have a stout pale or reddish outer coat. No Thwaites's number was recorded for *Xylaria Thwaitesii.* It appears to be a mixture from the sheets of *Xylaria involuta* in Herb. Kew.

One of the species in *Xylaria Thwaitesii* is certainly *Xylaria allantoidea.* The other, with larger spores, resembles *Xylaria zeylanica* in some respects, but its spores are larger and of a different shape. The latter appears to be a good species, for which the name *Xylaria Thwaitesii* may be retained. It has come under consideration as the probable cause of a root disease of *Hevea brasiliensis*, but although it has been collected on several occasions, mature examples have not yet been found in the field.

In one instance, the immature clavæ were clustered in rosettes up to 10 cm. in diameter. From a black basal stroma there arose three or four stout stalks, up to 2·5 cm. diameter and 4 cm. high, which divided above into numerous (as many as twenty) clavæ. The clavæ were all small, not exceeding 2 cm. in height and 1 cm. in diameter, shortly stalked, either clavate or subglobose, or laterally flattened, obversely triangular, and forked at the apex. The external layer was stout, pale brown or yellowish, splitting in drying, overlying the developing black layer.

Another set of specimens was developed from a *Hevea* root in the laboratory. These were connate at the base. The clavæ were either cylindric, tapering to a blunt apex, 5 cm. high, 5 mm. diameter, or thick and cylindric, 8 cm. high, 2 cm. diameter, narrowing abruptly at the tip, or flask-shaped, or flabelliform, 6 cm. high, 1–1·5 cm. thick, 1 cm. broad below, 5 cm. broad above, with the upper edge divided into triangular lobes. The apices in the cylindrical forms which narrowed abruptly above, and the triangular lobes of the flabelliform examples, were conidial, with oval, hyaline conidia, 9–10 × 4 μ, and they split off transversely as the stromata matured. The clavæ were pale brown, areolated, and under laboratory conditions they did not become brittle but somewhat corky. The perithecial loculi were globose, 0·4–0·7 mm. diameter. The sporiferous part of the ascus was 90–100 × 5–6 μ, and the tapering pedicel about 30 μ long. The spores were either narrow-cymbiform, with obtuse ends, 15–18 × 6–7 μ, or somewhat fusoid, with subacute ends, 14–18 × 3·5–4 μ.

In general appearance and diversity of shape, the specimens resemble *Xylaria plebeja*, but they are not so yellow, are usually larger, and their spores are different.

Xylaria flabelliformis (Schw.).—This was recorded for Ceylon by Berkeley and Broome in Fungi of Ceylon, No. 1041. The specimens were, as usual, conidial only. It has now been determined that, in Ceylon, this conidial form belongs to *Xylaria allantoidea*, though it is possible that other species may have the same type of conidial fructification. The conidial stage does not develop into the perithecial stage, but the two grow side by side from the same piece of wood, though, in general, the conidial stage has disappeared before the perithecial stage matures. It is an easy matter to grow the perithecial club from the pieces of wood which bear the conidial stage, but in the laboratory they all remain slender, and do not develop the hard outer crust or perithecia. The conidial stage and the immature perithecial stage are found together in nature fairly frequently, and in one or two instances the mature perithecial stage has been found with them. The pieces of wood on which this species grows are always strongly blackened externally.

Xylaria plebeja Ces.—This formed Thwaites 581, which was referred to *Xylaria rhopaloides* Mont. by Berkeley and Broome. It is the commonest *Xylaria* at Peradeniya, and very variable in form. Generally it is simple, cylindric, with an obtuse apex, up to 5 cm. high and 5 mm. diameter, but it may be ovate or spherical, terete or flattened. Among the Ceylon species known at present, it may be identified by its outer coat, which is pale yellow and splits into areolæ which persist until the stroma is effete. The base of the stalk is usually strigose with purplish mycelium. The spores are 9–10 × 4–5 μ.

Xylaria polymorpha Grev.—This was recorded for Ceylon by Berkeley from Gardner, Nos. 42 and 76. The specimens are immature, but are without doubt *Xylaria plebeja.*

Xylaria Hypoxylon Grev.—This was recorded by Berkeley and Broome in Fungi of Ceylon, No. 1046, from Thwaites 343. The specimen in Herb. Kew is marked 343 bis ; it is branched, but too immature for identification.

Xylaria apiculata Cke.—Thwaites 1115 was recorded by Berkeley and Broome as *Xylaria Hypoxylon* var. *mucronata.* It does not appear to be related to *Xylaria Hypoxylon,* and has been referred by Lloyd to *Xylaria apiculata* Cke. There is an abundance of specimens of this Thwaites gathering in

Herb. Kew and Herb. Peradeniya. The specimens are simple or branched, with a stalk from 1 to 12 mm. high, 1 mm. diameter, and a cylindrical clava from 3 mm. to 3 cm. long and 1·5 to 2·5 mm. diameter. The stalk is rigid, at first clothed with pale purple-brown, horizontally spreading hairs, becoming glabrous, irregularly furrowed. The clava is pale at first, the outer layer vertically fissured and persistent in longitudinal, often anastomosing, glabrous scales, equal, apex obtuse, or abruptly pointed ; ostiola minute, rounded. When old, the clava may become transversely wrinkled. The perithecia are oval or subglobose, about 0·4 × 0·3 mm., and the spores measure 13–17 × 6–7 μ. Berkeley and Broome's measurement was 15 × 7·5 μ.

This species is common at Peradeniya and Hakgala, and its extreme forms, if collected separately, might be taken for distinct species.

As noted above, the specimens of *Xylaria apiculata*, at Peradeniya, vary in height from 3 cm. to 3 mm. The smaller examples are often attenuated upwards, and conoid or wedge-shaped. At Hakgala another form is met with, usually on twigs and small branches not more than a centimetre in diameter. In this form the clava is generally irregularly globose, up to 2 mm. diameter, with an undulating scaly surface, sometimes rounded above, sometimes with a short conical mucro. In addition, examples occur in which the clava is cylindric or ovate, up to 4 mm. long and 3 mm. diameter, with a thin sterile apex ; and yet others which consist of a few scattered perithecia situated below the apex of a thin uniform stalk. The stalk of the globose form is rigid, about 0·4 mm. diameter, conical, clothed with spreading hairs, and varies from a height of about 3 mm. to almost nothing, the clava in the latter cases appearing sessile. With these small examples, there usually occur two or three specimens up to 3 cm. high with the normal clava of *Xylaria apiculata*. In these normal specimens the perithecia are about 0·4 mm. diameter, and the spores, 11–17 × 5–7 μ ; but in the small specimens, the perithecia are about 0·6 mm. diameter, and the spores 16–22 × 7–10 μ. The small globose or irregular forms have, in general, larger perithecia and spores. In one instance, of two specimens growing side by side, the larger, 3 cm. high, with a cylindrical clava, had spores 11–13 × 5–6 μ, while the smaller, 2 mm. high, with an irregularly globose clava, had spores chiefly 20–21 × 9–10 μ. But the spores varied in the latter from 12 × 6 to 20 × 10 μ in the same perithecium.

Another form, found up-country on decaying stumps, is indistinguishable externally from the common form of *Xylaria apiculata*, except perhaps that its mucro is often laterally compressed. But its perithecia are 0·8 mm. diameter, and its spores, 20–25 × 7–9 μ. One gathering of this form has spores, 14–26 × 6–8 μ.

Xylaria carpophila Fr.—This was recorded for Ceylon by Berkeley and Broome on the evidence of two collections, one on seeds of *Goniothalamus Hookeri*, and the other on seeds of *Diospyros Ebenum*. There is one specimen of each seed in Herb. Kew. The clavæ on *Goniothalamus Hookeri* are about 1 mm. in diameter, with a thin central core and a loose peripheral zone; they turn vivid purple with caustic potash, have long oval conidia up to 8 × 4 μ, and show the typical basidia of *Penicilliopsis*. They are indistinguishable from *Penicilliopsis clavariæformis*, but are conidial only. The specimens on *Diospyros* are also *Penicilliopsis*.

Xylaria tentaculata Rav.—The Ceylon specimens assigned to this species by Berkeley and Broome are conidial only. No. 576 contains filiform stromata up to 3 cm. high with simple spreading lateral branches. No. 641, also included under *Xylaria tentaculata* in Herb. Kew, is something quite different, probably not *Xylaria*.

Xylaria multiplex Fr.—To this species Lloyd refers *Xylaria Culleniæ* B. & Br., Fungi of Ceylon, No. 1047. It has stromata up to 12 cm. long, 3 mm. diameter below, tapering upwards, with an apex simple, or bifid, or multifid. The greater part of it is densely clothed with coarse purple-brown fascicles of septate hairs, up to 2 mm. long. The clava is short and slightly thicker than the stalk, or the stroma bears scattered perithecia over a considerable part of its length.

The perithecia are prominent, partly embedded in the superficial tomentum, with conical ostiola. The spores are broadly cymbiform, with obtuse ends, 8–10 × 4–5 μ. It would seem probable from the figure, that *Xylaria trichopoda* Penz. & Sacc. is the same species : Penzig and Saccardo give the spores of the latter as 12–13·5 × 5 μ.

Xylaria muscandæ Lloyd.—This has been described by Lloyd from Herb. Peradeniya, No. 3946, Peradeniya, January, 1914. The specimens are simple, sometimes connate at the base, with a total height up to 9 cm. The stalk is up to 2·5 cm. high, 1 mm. diameter, clothed with spreading purple-brown hairs. The clava is up to 7 cm. long, 2 mm. diameter below, terete, tapering regularly to the thin sterile apex, pale grey, rugose when dry, with slightly prominent ostiola. The perithecia are small, about 0·4 mm. diameter. The spores are broadly cymbiform, 9–11 × 4–5 μ.

Xylaria scopiformis Mont.—Berkeley and Broome recorded this species for Ceylon from Thwaites 613. There are two Ceylon gatherings in the cover of *Xylaria scopiformis* in Herb. Kew, 613 and 345, but the latter was recorded merely as immature *Xylaria*, indeterminable. The specimens of Thwaites 613 consist of simple or branched stromata, up to 6·5 cm. high, 1·2 mm. diameter, spirally twisted, pale grey, minutely rough with black, slightly projecting ostiola. The perithecia are small, subglobose, 0·3–0·4 mm. diameter. The spores are oval, inequilateral, or subcymbiform, ends obtuse, 7–9 × 3 μ. As pointed out by Lloyd, this is not *Xylaria scopiformis.* It is probably identical with *Xylaria muscandæ*, but no specimens exactly matching Thwaites 613 have been collected recently.

Xylaria nigripes Kl.—This species, which grows from termite nests, was named *Xylaria escharoidea* and *Xylaria Gardneri* by Berkeley from Ceylon specimens. It is assigned to *Xylaria nigripes* on the authority of Cooke. Additional synonyms are given in Ann. Perad., V., p. 333.

Xylaria furcata Fr.—This species occurs with *Xylaria nigripes*, growing from termite nests.

Xylaria myosurus Mont.—On dead wood, Peradeniya, December, 1911, No. 3328. This collection is referred to the South American species with some doubt by Lloyd.

Xylaria oocephala Penz. & Sacc.—On dead leaves, Peradeniya and Henaratgoda. In an immature gathering of this species from Henaratgoda, the stalks are up to 5 mm. high, 0·3–0·4 mm. diameter, slightly attenuated upwards, clothed at first with purple-grey spreading hairs. The clava is subglobose or ovate, up to 2 mm. high and 1 mm. diameter, with an apical point or seta, up to 5 mm. long, which readily breaks off. In the immature state, the clava is even, with a greyish, byssoid, outer coat and black projecting ostiola. When mature and weathered, it becomes black and often somewhat irregularly nodular. In one gathering from Peradeniya, the clavæ are subglobose, rounded above, flattened beneath, up to 2 mm. diameter, black, with scattered ostiola ; the stalks are up to 1 mm. high, but sometimes almost suppressed, so that the clava appears sessile. Long-stalked examples are frequently branched. The perithecia are globose, about 0·4 mm. diameter. The spores are broadly cymbiform, 12–13 × 6–7 μ.

Penzig and Saccardo give the spores of *Xylaria oocephala* as 9 × 3–4 μ. The stroma of the Ceylon species, however, resembles their figure so closely that it appears to be undoubtedly the same species. *Xylaria setocephala* Yates (Philippine Jour. of Science, XII., p. 379) is probably to be referred to this species. It is said to resemble *X. oocephala*, but to be distinguished by its long terminal seta, 5–8 mm. long, a distinction which does not appear to be valid in view of the Ceylon specimens. The spores of *Xylaria setocephala* are given as 13–15 × 6–8 μ. Lloyd regards *Xylaria setocephala* as identical with *Xylaria aristata* Mont.

Xylaria pyramidata B. & Br.—This was described by Berkeley and Broome from a single specimen. Half the head and a small part of the stalk are now in Herb. Peradeniya, and the remainder in Herb. Kew. In the type, the head is hemispherical in outline, laterally compressed, about 4 mm. diameter, concave below, rough with close-set, strongly projecting, conical ostiola, 0·2 mm. high. The head descends somewhat on both sides along the stalk, like the head of a *Spathularia*. The stalk is 3·5 cm. high, and 1·5 mm. diameter, longitudinally furrowed, with minute protuberances on the upper part. The perithecial cavities are small, globose, 0·2 mm. diameter, or vertically oval, 0·3 × 0·2 mm. The spores are cymbiform, 5–7 × 3–4 μ.

In a recent gathering, Peradeniya, January, 1919, the fungus grew on dead leaves. The specimens are from 1 to 2 centimetres high, and are quite different in shape from the type. The clava is ovate, about 2 mm. high and 1·5 mm. diameter, abruptly contracted below, sometimes with a thin apical seta about 1 mm. long. It is rough with strongly-projecting, conical ostiola, or in some cases consists of a group of close-set perithecia. The perithecia are rather soft, and they sometimes collapse, so that the conical ostiolum is surrounded by a depressed ring. The stalk is glabrous, longitudinally furrowed, and about 0·3 mm. diameter: for some distance below the clava it bears scattered globose perithecia. Probably the minute protuberances on the stalk in the type represent developing perithecia. The walls of the stalk and of the perithecia have a peculiar structure. When viewed under a magnification of forty diameters the stalk appears tessellated, and tangential sections show that it is composed of tabular cells, *i.e.*, it exhibits strong longitudinal "cell walls," united at close intervals by narrower cross walls, after the fashion of the epidermis of a monocotyledon. The walls of the perithecia, especially those on the stalk, have the same structure; the outer layer is blackish-brown, with strong parallel walls running like meridians from the base to the apex; these meridians are united by a few thick walls which run across three or four of them somewhat irregularly, and by numerous thinner walls which run perpendicularly from one meridian to the next: the wall is thus divided into more or less rectangular cells, about 16 μ broad and 10 μ high. The structure of the perithecial wall recalls the net of *Dictydium cancellatum*. The sporiferous part of the ascus measures about 70 × 5 μ, and is followed by a tapering pedicel about 40 μ long. The spores are uniseriate, or slightly obliquely uniseriate. Numerous linear paraphyses are present. In this collection the spores are broadly cymbiform, with obtuse ends, 7–9 × 4–4·5 μ, and are furnished with a thin, hyaline coat.

Xylaria hæmorrhoidalis B. & Br.—This was described by Berkeley and Broome in Fungi of Ceylon, No. 1035. Under this name in Herb. Kew is a sheet marked 31, 582, 642. It includes specimens marked by Berkeley, *X. hæmorrhoidalis*, *X. digitata minor*, and *X. Schweinitzii*. The first is subglobose, the second clavate, and the third ovate, with long or short stalks. The specimens marked *X. digitata minor* are immature. Those marked *X. Schweinitzii* are *X. hæmorrhoidalis*.

In Fungi of Ceylon, No. 1037, Berkeley and Broome recorded *Xylaria Schweinitzii*, from Thwaites 642 in part. The specimens in the cover of *X. Schweinitzii*, in Herb. Kew are again *X. hæmorrhoidalis*.

Under *Xylaria hæmorrhoidalis*, in the Fungi of Ceylon, Berkeley and Broome wrote " No. 66 is probably the conidiferous state of this species, or *X. anisopleura* Mont. The stem is naked below, much branched above, and bearing abundant, nearly globose conidia ·0002 (inches) in diameter." Under *Xylaria anisopleura*, they referred to the same gathering in the words, " Conidia globose, ·0002 in diameter."

Xylaria anisopleura Mont. was recorded in Fungi of Ceylon, No. 1044, from Thwaites 66 and 31 in part. No. 66 is the conidial form referred to above, and it is very doubtful whether it is related to any *Xylaria*. In Herb. Kew, under *X. anisopleura* are the conidial form, Thwaites 66 ; a sheet, part of Thwaites 31, marked " *Xyl. anisopleura* Mont., *Xyl. hæmorrhoidalis* B. & Br., with *Xylaria digitata minor*," which is the same mixture as Thwaites 31, 582, 642, in the cover of *X. hæmorrhoidalis ;* and another sheet, part of Thwaites 31, marked " *X. anisopleura* Mont." only. The latter is an extreme form of *X. hæmorrhoidalis*, with strongly projecting perithecial elevations up to 2 mm. diameter, and spores 20–24 × 6–8 μ, with a few broader, 10 μ.

Xylaria hæmorrhoidalis is a common species at Hakgala (5,600 ft.) and not rare at Peradeniya. In general, it is globose or ovoid and almost sessile, usually about a centimetre in diameter. From this it varies in both directions. In some gatherings, the stromata are pulvinate, circular, up to 3 mm. diameter and 1·5 mm. high, with a flat base, centrally attached, and would be assigned to *Penzigia*. In others, they are obovate, 1 cm. high, 6 mm. diameter, narrowed below into a stem-like base, while in the extreme form in this direction, they have an ovate or conical clava and a distinct stalk.

The stromata are at first covered with a thick, greyish, pulverulent coat, which cracks into scales and weathers off, leaving the stromata black. The surface of the smaller stromata is almost even, but the larger are tuberculate, the perithecial elevations being up to 1 mm. diameter. The ostiola are minute and conical. The perithecia are large, oval, up to 1·25 mm. high and 0·75 mm. broad. The sporiferous part of the ascus is 140–170 × 7–10 μ, the spores being uniseriate, alternately arranged. The spores are black-brown, narrow-cymbiform, straight or slightly curved, ends obtuse, 18–34 × 6–10 μ. Linear paraphyses are present. The stroma is compact, not brittle, white internally, and is easily cut.

Cesati recorded for Ceylon, *Hypoxylon glebulosum*, and a specimen from him is in Herb. Kew. The stromata are turbinate, not tuberculate, about 4 mm. diameter and 2·5 mm. high. The outer coat is not weathered off. The spores are 27–34 × 7–8 μ. This is *Xylaria hæmorrhoidalis*. Although the Kew specimens are turbinate and not tuberculate, Cesati's figure shows a stalked specimen, more strongly tuberculate than any I have seen. He gave the spores as 12 × 5–6, but as his unit was 2 μ, this is 24 × 10–12 μ. He notes that Cooke's measurement from his specimens was 30–32 × 7·5 μ.

Cesati's figures of *Xylaria massula* and *Hypoxylon avellana* strongly resemble *Xylaria hæmorrhoidalis*, but he gives the spores as 16 × 10 μ and 16–20 × 6 μ respectively, noting at the same time that Cooke made the spores of *Hypoxylon avellana*, 35 × 10 μ.

Measurements from the type of *Xylaria hæmorrhoidalis* gave the spores 23–28 × 7–9 μ; others from recent collections are 24–30 × 8–10 μ; 24–28 × 8–10 μ; 27–34 × 7–8 μ; 18–23

× 6–7 μ, with a few 10 μ broad. The arrangement of the spores, back to back, in the ascus is peculiar.

The Ceylon specimens assigned to *Xylaria anisopleura* appear to me to be merely extreme forms of *X. hæmorrhoidalis.* Berkeley and Broome's specimen is a stalked form. Lloyd assigns to *X. anisopleura,* a recent recollection which grew from a buried root of a dead tree. The clava in these latter is globose, with a well-defined stalk, and the stalks are in some cases branched. But it has to be recorded that the stalks were entirely below ground, and only the globose clavæ appeared above the surface. Lloyd considers that if this form is *Xylaria hæmorrhoidalis,* it will not be possible to keep that species distinct from *X. anisopleura.*

The conidial form referred alternatively to *Xylaria anisopleura* or *X. hæmorrhoidalis* by Berkeley and Broome has been collected on several occasions at Peradeniya. It grows on the ground, and resembles a large *Isaria,* up to 12 cm. high, with a loosely-branched head up to 5 cm. diameter. The stalk is black and rooting. It bears numerous sub-erect branches, which divide repeatedly and are plumose above, the ultimate branchlets being more or less perpendicular to the main branches. The whole fungus is cartilaginous and subtranslucent. It does not, in the fresh state, resemble a conidial *Xylaria,* and no *Xylaria* has been observed to develop from it, or to succeed it. It certainly bears no relation to *Xylaria hæmorrhoidalis.*

Xylaria vagans Petch.—This species is fairly common on dead leaves at Hakgala. It was described and figured in Ann. Perad., VI., p. 68, plate VII.

Poronia.

Poronia macrorrhiza Speg.—This was collected in well-manured potting soil at Hakgala, December, 1905.

Poronia minuta Petch.—Frequent on hare's dung, Peradeniya.

Kretzschmaria.

Of the *Xylariaceæ* enumerated by Berkeley and Broome in the Fungi of Ceylon, four have been referred to *Kretzschmaria,* viz.; No. 1051, *Hypoxylon cœnopus* Mont. var. *apoda;* No. 1052, *Hypoxylon clavus* Fr.; No. 1053, *Hypoxylon micropus* Fr.; and No. 1054, *Hypoxylon congestum* B. & Br.

Cooke placed these four in his genus *Rhopalopsis;* and in Grevillea, XII., p. 2, he described *Rhopalopsis Berkeleyanum*, which included Glaziou 8542, 8543 from Brazil, and *Hypoxylon cœnopus* var. *apoda* (Thwaites 60) from Ceylon. Berlese & Voglino transferred this to *Kretzschmaria* (Add. Syll, p. 56).

In the cover of *Hypoxylon clavus* at Kew are the Ceylon specimens collected by Thwaites in 1851; Thwaites 581, cited by Berkeley and Broome, is missing, but this number may have been accidentally evolved from the date. Thwaites 581 at Kew and Peradeniya is a *Xylaria*, labelled *X. rhopaloides*. The specimens collected by Thwaites in 1851 are practically unrecognizable, and, as far as they are concerned, *Hypoxylon clavus* may be deleted from the Ceylon list. Cooke (Grevillea, XII., p. 2) gave the spores of *Hypoxylon clavus* as 40 × 10 μ, and Theissen (Ann. Myc., VII., p. 8) stated that they measure 30–42 × 6–9 μ. There are no available Ceylon specimens of *Kretzschmaria* with spores of those dimensions.

Hypoxylon congestum was described by Berkeley and Broome in Fungi of Ceylon, No. 1054. There is no reason why it should have been transferred to *Kretzschmaria*. The stroma is pulvinate or subglobose, about 1 cm. broad, hard, but not carbonaceous, dark green internally, with a distinct, thick cortex which splits off when one tries to cut the stroma. This stroma is densely covered with erect processes, either clavate, up to 2 mm. high and 0·8 mm. diameter, or pulvinate, 0·8 mm. diameter. The surface is somewhat fibrillose. In the body of the stroma, as seen in section, are indistinct oval lines which appear to be the walls of developing perithecia. Evidently, when mature, the stroma would contain perithecia of which the processes would be the ostiola. The structure is the same as that of *Pleomelogramma rugosa*, described in this paper, but it differs from the latter in several details, and would appear to be a different species. Berkeley and Broome stated that the spores are subglobose, 12·5–17·5 μ diameter, and Cooke (Grevillea, XII., p. 2) gave the spores as 15–17 ×

13–15 μ. Black-brown, opaque, spherical spores, 10–15 μ diameter, are present, but they are conidia, borne on the external fibrillose layer. The specimens are immature, and there is no evidence that the species is a *Hypoxylon.* Alcohol and caustic potash give a green extract.

Thwaites 60 contained two species, which Berkeley and Broome assigned to *Hypoxylon cœnopus* Mont. var. *apoda,* and *Hypoxylon micropus* Fr. respectively. The citation of *Hypoxylon cœnopus* var. *apoda* in the Fungi of Ceylon is apparently the first publication of the variety, but it was not accompanied by any description. *Hypoxylon micropus* Fr. is apparently *Sphæria micropus* Fr., Linn., V., p. 542. In Saccardo, it is listed in Vol. I. as *Hypoxylon micropus* (Fr.) Sacc. ; in Vol. II., XXIX., and Vol. IX., p. 565, it appears as *Kretzschmaria micropus* (Berk.), while Vol. XV. gives *Sphæria micropus* Fr.=*Kretzschmaria micropus* Sacc., II., XXIX., and IX., 565.

Herb. Peradeniya has Thwaites 60, both species. In Herb. Kew the cover of *Hypoxylon micropus* contains a specimen, Thwaites 60, Dec., 1868, marked "sent before." This is the number and date quoted by Berkeley and Broome for the Ceylon specimen of *Hypoxylon micropus.* The specimen has spores 29–34 × 6–9 μ, elongated cymbiform. In the cover of *Hypoxylon Berkeleyanum* in Herb. Kew are two Ceylon specimens. One of them, Thwaites 60, Nov., 1867, is marked *Hypoxylon cœnopus* var. by Berkeley, and subsequently "not *H. cœnopus*" in an unidentified handwriting ; it has spores 7–9 × 3·5–5 μ. The other is Thwaites, Sept. 10, 1850, marked *Sphæria cœnopus* by Berkeley, and "This is *cœnopus*" in the same unknown handwriting as before ; but its spores measure 28–32 × 9–11 μ, and it is identical with Berkeley and Broome's specimen of *Hypoxylon micropus.* Evidently, Thwaites was correct in stating that he had sent it before. There is no Ceylon specimen in the cover of *Hypoxylon cœnopus* at Kew ; apparently the two specimens just noted were transferred to the cover of *Hypoxylon Berkeleyanum* by Cooke.

When Cooke described *Rhopalopsis Berkeleyanum,* he gave *Hypoxylon cœnopus* var. Berk. as a synonym and cited the specimens, Glaziou 8542, 8543, and Ceylon 60. There were two species in Ceylon 60, but we may take it that Cooke referred to the specimen with spores about 10 μ long, *i.e.*, Berkeley's *Hypoxylon cœnopus* var. *apoda.* I have not examined both the Glaziou numbers, but only No. 8542, since, if the specimens are not the same species, 8542 is the type. Examination shows that this specimen is not the same as Berkeley's *Hypoxylon cœnopus* var. *apoda.* The spores of the two are about the same length, but the stromata differ in essential points, especially in the character of the ostiola, which appears to be of specific value in this group.

Kretzschmaria Berkeleyana (Glaziou 8542) has obconic stromata which taper below into a stalk ; the upper surface of the stroma is plane, irregularly circular, and the sides are rugose. The stalks and upper parts of the adjacent stromata are free. The head is about 3 mm. in diameter, and the total height about 7 mm., of which the thin stalk (0·5 mm. diam.) constitutes one half. The ostiola are scattered and sub-hemispherical. The perithecia are numerous in each stroma, thick-walled, and the perithecial cavities oval, 0·5 mm. deep, 0·3 mm. diameter ; the perithecial wall is reddish in section. The spores are black-brown, broadly cymbiform, ends obtuse, 8-10 × 5–6 μ.

Kretzschmaria cœnopus var. **apoda** Berk. has obconic stromata which taper uniformly to the base as a rule, but are sometimes attenuated below into a stalk. The upper surface is polygonal, slightly convex, about 4 mm. in diameter. The total height is about 4 mm. The adjacent stromata are either free, or fused above into a continuous mass. The ostiola are minute, conical, and obscurely annulate. The perithecia are numerous in each stroma, irregularly oval, 0·6 mm. deep and 0·3 mm. diameter. The spores are cymbiform, brown, ends obtuse, 7–9 × 3·5–4 μ. This is apparently quite different in shape of stroma and size of spores from *Kretzschmaria cœnopus* Mont. Cooke (Grevillea XII., p. 2, gave the spore of *Rhopalopsis cœnopus* (Mont.) as lanceolate) 40–45 × 9 μ. Currey (Trans. Linn. Soc., XXII., p. 263) stated that the spores in a specimen of *Hypoxylon cœnopus* Mont.

from Guiana, *ex* Leprieur and Montagne's collection, were 25 μ long. Saccardo (Sylloge, I.) gave the spores 10 μ long on the authority of Berkeley, but this is probably the measurement of the spore of var. *apoda* from the Fungi of Ceylon. Lloyd gives the spores of *Kretzschmaria cœnopus* as 28 × 8 μ, and his photograph of the stroma matches specimens received from the West Indies. It would appear desirable to make the Ceylon fungus a distinct species, for which the name *Kretzschmaria turbinata* is proposed. The specific name *apoda* has already been applied by Lloyd to a South American species (Myco. Notes, No. 66, p. 1120). Lloyd (The large Pyrenomycetes, second paper, p. 22) suggests that Berkeley's var. *apoda* is identical with Cesati's *Hypoxylon glebulosum* from Ceylon and with *Kretzschmaria sessilis* from South America. Cesati's species, however, is certainly different, and is the same as *Xylaria hæmorrhoidalis*. *Kretzschmaria turbinata* has been collected recently at Peradeniya.

Kretzschmaria micropus (Fr.), as determined by Berkeley, is a common species in Ceylon, and has recently come into prominence as a wound parasite of *Hevea*. It occurs in patches up to 10 cms. in diameter, the individual stromata being fused together into a continuous mass. It arises first either as a number of *Stilbum*-like stalks scattered over a considerable area, or more generally as a cluster of stalks from one point. These stalks attain a height of about one centimetre and branch above, the ultimate branchlets being short. This fructification, which is the conidial stage, resembles a group of conidial *Xylarias*, or, in shape, a compound *Clavaria*. The branches subsequently become inflated at the apex, each producing a perithecial stroma. The whole group now becomes compact and pulvinate, the outer stalks being pressed outwards into close contact with the substratum. It is not uncommon to find examples in which the centre consists of perithecial stromata, while the outer branches are conidial, like miniature stag's horns. The lower surface of the compound stroma presents a network of stalks, usually radiating from the centre and fused together at intervals. The individual stromata are, in general, fused together above.

Under certain conditions, as, for example, when the fructification develops on one side of a log near the ground, the upper part of the compound stroma may be normally developed, while the lower part, in contact with the soil, is composed of a cluster of quite separate stalks, two to three centimetres in length, each bearing a perithecial stroma. With the more luxuriant growth in the damper position, the stalks and stromata become widely separated and consequently cannot fuse. This is the condition figured by Cesati (Mycetum in itinere Borneensi lectorum, pl. III.), his illustration showing an isolated perithecial branch.

The individual stromata are at first grey, finally black, clavate, upper part globose, or ovoid, or angular through mutual pressure, sometimes acutely conical above, but more generally rounded, attenuated below into a stalk : they are about 2 mm. in diameter and 5 to 10 mm. high. The stalks vary from erect to horizontal, according to position, and are fused together here and there into an irregular labyrinthoid mass. Each individual stroma contains one to five perithecia ; the ostiola are conical and prominent, the perithecia large and oval, up to 1·4 mm. deep, and 1 mm. diameter. The spores are elongated-cymbiform, straight or curved, black-brown, ends rounded, 28–33 × 6–7 μ in Thwaites 60 in Herb. Peradeniya. Thwaites 60 in Herb. Kew, *sub. H. micropus* has spores 29–34 × 6–9 μ ; while Thwaites of September, 1850, in Herb. Kew, *sub. H. Berkeleyanum*, has somewhat broader spores, 28–32 × 9–11 μ.

The brief description of *Hypoxylon micropus* (Fr.) may be taken to fit the Ceylon species. The upper surface of the individual stroma is rounded, if the perithecial stroma develops at the apex of the stalk, but it has an acute conical umbo if the stroma develops just below the apex so that the tip of the conidial stroma persists. In Saccardo, the spores are said to be 30–38 × 9–12 μ. The latter is Cooke's measurement, *ex* Grevillea, XII., p. 2, the source of the specimen examined not being stated. Berkeley and Broome gave the spores of the Ceylon specimen as 30 μ long. This species would appear to be doubtfully distinct from *Kretzschmaria cetrarioides* (Welw. & Curr.), but it is certainly what Berkeley regarded as *Hypoxylon micropus.*

To the species enumerated above, the following, apparently undescribed, species is to be added.

Kretzschmaria sphærocephala n. sp. Total height up to 5 mm. Head subglobose, about 3 mm. diameter, sometimes compressed and reniform, contracted suddenly below into a regular, terete, erect stalk, 1–2 mm. diameter. At first greyish-white, bearing hyaline, oval conidia, 4 × 2 μ ; becoming glabrous, smooth, brittle, coffee-coloured, finally black. Ostiola not projecting ; perithecia oval, peripheral, 0·5 mm. deep, 0·3 mm. diameter, paraphyses long and abundant. Spores narrow-subcymbiform, almost cylindric in one aspect, ends very obtuse, 14–16 × 4 μ ; a few, 10 × 4 μ. In rows or groups, stalks erect and separate, occasionally branched but usually simple, heads fused or distinct. On dead branches of *Bombax malabaricum* DC., Peradeniya.

Ustulina.

Ustulina zonata Lev. A common species, which causes root disease in tea, *Hevea*, &c. It was recorded for Ceylon by Berkeley and Broome as *Ustulina vulgaris* Tul., and by Cesati as *Hypoxylon deustum* Fr. It was re-described in Ann. Perad., V., p. 286.

Penzigia.

The genus *Penzigia* was established by Saccardo in Saccardo and Paoletti, Mycetes Malacenses. The generic description is—

> " Stroma subglobosum vel hemisphæricum vel obpiriforme, intus plerumque radiato-fibrosum (nunquam concentrice zonatum) extus crustaceo-laccatum (pallens), leve ; perithecia stromate omnino immersa, collis brevibus vel subnullis ; ostiola punctiformia non extantia ; asci octospori, paraphysati stipitati ; sporidia oblongo-fusoidea, majuscula, fuliginea."

Penzigia was said to differ from *Daldinia* in its pallid stroma, not concentrically zoned within, and from *Xylaria* in its subglobose stroma with perithecia entirely immersed. The type species is *Penzigia cranioides* Sacc. and Paol. ; it was " crustaceo-fragili, pallide vel sordide argillaceo, minutissime nigro-punctato," with perithecia " extus argillaceis."

Saccardo and Paoletti referred to the new genus, *Hypoxylon cretaceum* B. & Br. and *Xylaria compuncta* (Jungh.), while they gave a description, under the name *Penzigia dealbata* (B. & C.), of a specimen which they considered identical with *Xylaria dealbata* B. & C.

The precise nature of *Penzigia* has always been in doubt. Saccardo and Paoletti, by their inclusion of *Xylaria compuncta*, would make it appear equivalent to *Sarcoxylon* Cooke. Theissen (Ann. Myc., VII., p. 5) discussed the question, and agreed with Rehm that it should be limited to forms which are intermediate between *Xylaria* and *Hypoxylon*. " In that sense, *Penzigia* includes species with a reduced foot, 'basi stipitiformi,' or species apparently sessile, which in median longitudinal section exhibit an evident continuation of the vertical hyphæ of the stalk into the radial stroma." He considered that *Penzigia* is not identical with *Sarcoxylon*, as the latter does not have a hard crustaceous cortex.

The characters assigned to the genus by its author are insufficient to distinguish it from allied genera. Some species of *Xylaria*, *e.g.*, *X. allantoidea*, are internally " radiato-fibrosum," and very many have totally-immersed perithecia. In *Xylaria allantoidea*, too, the stroma varies from cylindric or clavate to globose, and in *Xylaria hæmorrhoidalis* the stroma is generally globose. Several species of *Xylaria* are light-coloured externally until old and weathered, *e.g.*, *Xylaria exalbata*, which is white or grey, and *Xylaria plebeja*, which is pale yellow.

The description leaves us in doubt as to the nature of cortex of the stroma, which is one of the critical characters. Many *Xylariaceæ* which are black and crustaceous when old have at first a pale-coloured layer overlying the black cortex of the stroma. *Ustulina zonata*, for example, is at first grey or purple-grey, or sometimes almost white; *Kretzschmaria micropus* is greyish-white at first; *Xylaria exalbata* and *Xylaria plebeja* have already been referred to in this respect. The phrase " crustaceo-laccatum " suggests that a similar condition occurred in the type specimen of *Penzigia*.

That *Penzigia* is identical with *Sarcoxylon* would seem doubtful. As Cooke made *Sarcoxylon compunctum* the type species of his genus, the decision of the question must rest upon an examination of the original specimen of *Sphæria compuncta*, but the species assigned to *Sarcoxylon* in Ceylon, viz., *Sarcoxylon aurantiacum* Pat. and *Sarcoxylon lycogaloides* (B. & Br.) Cooke, are not "crustaceo-laccatum" nor "crustaceo-fragile."

The shapes enumerated by the author in the generic description of *Penzigia* would appear to have been included in order to cover the species other than the type which were considered co-generic. *Penzigia cranioides* was described as "Stromate e basi applanato vel leniter excavato globoso-hemisphærico," and a reference to the figure shows that it was hemispherical, with a more or less flat base, attached only in the centre of the base. *Penzigia macrosporum* Penz. & Sacc., as figured in Icones Fungorum Javanicorum, Tab. XIX., fig. 4, has the same character; it is flattened pulvinate, closely applied to the substratum, but only centrally attached.

This central attachment is a consequence of the mode of growth of the fungus. In the common effused species of *Hypoxylon*, the fructification arises from the substratum over a wide area, and the whole of the base is firmly attached to the wood or bark. In the type species of *Hypoxylon*, *H. coccineum*, the area of attachment is contracted, but it is nevertheless the whole base; and the same is true of *Sarcoxylon aurantiacum* and *Sarcoxylon lycogaloides*. In *Xylaria*, the developing fructification grows out at right angles to the substratum in a narrow column; the clava may become obovate or even globose, but the course of its constituent hyphæ is sub-erect. On the other hand, *Ustulina*, as exemplified by *Ustulina zonata*, begins to develop as an erect column of hyphæ, exactly like a *Xylaria*, but the hyphæ soon change their direction, and spread out horizontally over the substratum. Consequently the fructification of *Ustulina zonata* is a thin plate, closely applied to the substratum, but attached only by a comparatively thin column in the centre. If the point of a penknife be inserted under the edge of a stroma of *Ustulina zonata*, the stroma can be prised off entire with very slight effort, but it is impossible to separate an effused *Hypoxylon* from its host by that means. *Penzigia*, as illustrated by the type species, and by *Penzigia macrosporum*, partly resembles *Ustulina* in this respect; its hyphæ grow out, sometimes in all directions, sometimes chiefly horizontally, from the short column which first emerges from the matrix; hence it has a flat base and is only centrally attached.

Whether the character indicated above will suffice to distinguish *Penzigia* cannot be decided without an examination of the type specimen. On that character, *Penzigia* is, in shape, a *Hypoxylon* with a more or less flat base, attached only in the centre. The stroma may be said to be button-shaped, the shank of the button being represented by the central column of attachment. This character, however, is not exclusively confined to *Penzigia*; stromata of the same shape may occur in *Xylaria hæmorrhoidalis*.

In the structure of the cortical layer and the internal tissue of the stroma, *Penzigia* more closely resembles *Xylaria* than *Hypoxylon*.

The Ceylon species which have been assigned to *Penzigia* are *Penzigia compuncta* (Jungh.) Sacc. & Paol., and *Penzigia lycogaloides* (B. & Br.). Both these are here referred to under *Sarcoxylon*. Another of Berkeley and Broome's species, *Sphæria Eterio*, is *Penzigia* in the sense noted above, while two undescribed species have been collected recently.

Penzigia Eterio (B. & Br.). This was described by Berkeley and Broome as *Sphæria* (*Confluentes*) *Eterio*. In Saccardo, I., 305, it was listed as *Anthostoma Eterio*. Cooke (Grevillea, XI., 130) transferred it to *Hypoxylon*. The stromata are small, superficial, circular, up to 2 mm. diameter, pulvinate or flattened pulvinate, with a rounded margin, base flat, attached to the substratum only in the centre. The surface is grey-brown, pruinose, feebly tuberculate, the somewhat obscure perithecial elevations measuring 0·3–0·4 mm. diameter. The ostiola are black, prominent, minute, papillate. The stroma is reddish-white internally, with a dark-brown outer crust 0·06 mm. thick. The perithecia form a definite peripheral layer, and are oval or globose, 0·2–0·4 mm. diameter. The spores are black-brown, opaque, elliptic, ends obtuse, 8–10 × 4–5 μ.

Penzigia poroniæformis n. sp. Stromata circular, up to 2 cm. diameter, rather thin, 2–3 mm. thick, convex above, concave below, attached by a central stalk, the edge of the stroma being in contact with the substratum : surface undulating or even, without perithecial elevations, margin crenate or ridged ; white, then black. Cortex of stroma black, carbonaceous, about 0·1 mm. thick ; internal tissue white, somewhat corky. Frequently growing in clusters of three or four, and then irregularly distorted. Ostiola scattered, obtusely conical. Perithecia oval, up to 0·8 × 0·5 mm. Perithecial wall pale yellow-brown, pale-yellow by transmitted light, membranous. Spores black, opaque, oval or broadly cymbiform, 9–12 × 6–7 µ. Asci, 80–96 × 7 µ. On dead wood, Hakgala ; frequent. Type, No. 4568 in Herb. Peradeniya.

Penzigia placenta n. sp. Stromata scattered or clustered, up to 8 mm. diameter, circular, or distorted through mutual pressure ; isolated specimens pulvinate, up to 3 mm. thick, base flat and plicate : clustered specimens up to 5 mm. thick, irregularly contracted below, sometimes subturbinate ; purple-grey, becoming black ; surface even, without perithecial elevations ; cortex black, carbonaceous, about 0·1 mm. thick : internal tissue white ; ostiola scattered, minute, conical. Perithecia oval, up to 0·6 × 0·4 mm. Wall of perithecium membranous, pale brownish–yellow. Asci 110–125 × 8 µ, with a long pedicel. Spores opaque, black, oval, slightly inequilateral, or broadly cymbiform, 12–15 × 7–8 µ. On dead *Hevea*, Henaratgoda, March, 1910. Type, No. 3167 in Herb. Peradeniya. Differs from the foregoing in its flat base and larger spores.

Sarcoxylon.

The genus *Sarcoxylon* was established by Cooke in Grevillea, XII., p. 50, for the reception of two species, *Sphæria compuncta* Jungh., and *Hypoxylon lycogaloides* B. & Br. The generic description was " Stroma rather fleshy, pallid, or brightly-coloured, subglobose, pulvinate, or depressed, perithecia submembranaceous, sporidia simple, coloured." Cooke's genus was not accepted when proposed, but it appears to be well-founded, and is now generally recognized. The underlying idea would seem to be a hypocreaceous stroma with the spores of a *Hypoxylon*. It may be noted that the two species included by Cooke would not be regarded as co-generic at the present day. *Sarcoxylon lycogaloides* differs in its strongly tuberculate spores.

Sarcoxylon lycogaloides (B. & Br.) Cke. This species is known only from the type. The specimens were apparently subglobose and soft, and have been compressed in drying. They are about 5 mm. in diameter, and seated, sometimes crowded, on a thin sheet of mycelium. Berkeley and Broome stated that they were yellow. They appear to have been verrucose when fresh, and the ostiola black, slightly projecting. The cortical layer is yellow-brown, scarcely differentiated from the tissue of the stroma. The perithecia are contained in a peripheral layer, and are oval, about 0·4 mm. deep and 0·2 mm. diameter. The wall of the perithecium is yellow or yellow-brown. The spores in the asci are uniseriate, the sporiferous part of the ascus measuring 140–160 × 12–14 μ. The spores are oval, brown, 18–23 × 11–14 μ, studded with rounded tubercles which are 4 μ in diameter and 3 μ high.

Sarcoxylon aurantiacum Pat. This species, kindly identified by Mr. C. G. Lloyd, is fairly common in the low-country of Ceylon, though it is not often collected in a mature state. It is irregularly subglobose, contracted and often plicate below, up to 5 cm. diameter, frequently growing in clusters. The immature stromata are yellowish-red, pruinose, fleshy; on sectioning them a brick red peripheral zone is found. The internal tissue is radially fibrous in these immature specimens. When mature, the stromata are deep red-brown, glabrous, almost laccate, even, or with minute perithecial elevations. The ostiola are not evident. The internal tissue becomes greyish and watery, and finally subgelatinous, and on drying the stroma may either collapse irregularly or become hollow. The perithecia are situated in a black peripheral zone, about 1 mm. deep, and are oval or cylindrical, up to 0·5 mm. high and 0·2 mm. diameter. The wall of the perithecium is brown and membranous. The tissue between the apices of the perithecia is red-brown by transmitted light and, like the cortex, yields a red-brown extract with alcohol. The cortex is soft, 100–200 μ thick, red-brown in thin sections. At the base of the perithecial layer the tissue becomes black-brown and rather loose. The asci are clavate, long pedicelled, the sporiferous part measuring 60 × 10 μ. The spores are oval, black-brown, 9–16 × 6–7 μ, with a few globose, 6 μ diameter.

This species is very difficult to dry, and specimens usually become mouldy in drying naturally. Though fairly common, its development appears, in very many cases, to be arrested before the perithecia are formed, and it was collected on several occasions in Ceylon before mature specimens were obtained from which its systematic position could be determined.

Sarcoxylon compunctum (Jungh.) Cooke. This species was recorded for Ceylon by Berkeley and Broome in Fungi of Ceylon, No. 1056, as *Hypoxylon compunctum* Jungh. They gave the dimensions of the spores as 17·5 × 7·5 μ. In Saccardo, Sylloge Fungorum, I., p. 325, it is described, under *Xylaria compuncta* (Jungh.) Berk., as " Globoso-difformis, basi constricta, glabra, alutaceo-pallida, nigro-punctata, intus pallida, radiatim fibrosa ; peritheciis maximis concentricis, globoso-ovoideis ; sporidiis ovoideo-oblongis, 12–14 × 7–8 μ, fuscis." Though Berkeley listed it as *Xylaria* in Decades 482, he referred it to *Hypoxylon* in the Fungi of Ceylon.

Fries, in Novæ Symbolæ, p. 130, referred this species to *Hypoxylon*, and described it as " Maximum, rotundatum, basi constrictum, extus intusque albidum, stromate e ' carnoso ' suberoso a basi radiante, peritheciis immersis periphicis uniserialibus ovatis ostiolisque punctiformi-prominulis nigris."

In Herb. Peradeniya, the Ceylon gathering attributed to *Hypoxylon compunctum* by Berkeley and Broome, Fungi of Ceylon No. 1056, is represented by sections of one specimen. The exterior is pale yellow, with a matted tomentose surface, dotted with black, slightly-projecting ostiola. The perithecia are situated in a peripheral layer, about 2 mm. deep, which forms a continuous black zone in section ; they are cylindric, up to 2 mm. high and 0·4 mm. diameter, and the spores are broadly oval or subcymbiform, 12–15 × 6–7 μ. When examined microscopically, the tissue between the apices of the perithecia is red-brown, and it yields a red-brown extract with alcohol. The wall of the perithecium and the spores are stained red-brown, probably because the specimen has been treated with an alcoholic preservative. The internal tissue is obscurely radially fibrose. The cortical layer is 100–150 μ thick, not carbonaceous, and in thin sections is red-brown. The wall of the perithecium is membranous. This specimen differs from *Sarcoxylon aurantiacum* in its larger perithecia. It also differs from both *Sarcoxylon aurantiacum* and *Sarcoxylon compunctum* in having a tomentose surface. It would seem probable, however, that this surface layer of tomentum is due to a growth of a hyphomycete over the fungus when drying, and in view of the fact that the cortex is red-brown, I am of opinion that the specimen is to be attributed to *Sarcoxylon aurantiacum.*

Sarcoxylon spathulatum (B. & Br.). This was described by Berkeley and Broome as *Xylaria spathulata.* There was apparently only one specimen, half of which is now in Herb. Kew and the other half in Herb. Peradeniya. The type in Herb. Kew is marked *Xylaria spathularia* by Berkeley, and it derived that name from the manner in which the head is continued down either side of the stalk, " as in *Spathularia,*" but the name was published as *spathulata.* The specimen is about 3 cm. high, broadly ovate, compressed laterally (? in drying), 1.7 cm. broad at the widest, rounded above, narrowing below into a stalk 4 mm. diameter. The head is chestnut-brown, glabrous, with barely-projecting black ostiola ; it is clearly defined from the stalk, and is continued slightly down either side of the latter. The stalk is darker than the head, rooting, apparently glabrous above, but spongy tomentose (?) on the embedded portion. The cortical layer is brown, not carbonaceous, only about 25 μ thick. The perithecia form a peripheral layer, two or three deep : they are small, subglobose or ovoid, up to 0·4 mm. high and 0·3 mm. diameter. The wall of the perithecium is brown and membranous, about 20 μ thick. The perithecia have yellow-brown cylindric necks, up to 1 mm. long, the length depending upon the depth of the perithecium in the stroma. The spores are brown, broadly oval, sometimes slightly pointed at one end, 5–6 × 3 μ. This is probably identical with *Xylaria polysticha* Penz. and Sacc., these authors having been misled by Cooke's figure which shows a single layer of perithecia. In structure it is clearly *Sarcoxylon,* though in shape it resembles *Xylaria* rather than *Hypoxylon.*

Hypoxylon.

In Sylloge Fungorum, I., Saccardo arranged the known species of *Hypoxylon* in four groups, viz., *Eu-hypoxylon, Placoxylon, Endoxylon,* and *Cœnopus.* Species of the last group are now referred to *Kretzschmaria. Eu-hypoxylon* included species with a superficial, globose, pulvinate, or subeffused stroma, and was divided into two sections (*a*) with a stroma externally coloured, and (*b*) with a stroma black, or fuscous becoming black. *Placoxylon* included species with a subsuperficial, widely effused stroma, and was divided into two groups on the same characters as *Eu-hypoxylon.*

Cooke, in Grevillea, XI., p. 121, divided the genus into six sections. His arrangement of the Ceylon species is as follows :—

III. *Sphæroxylon.*—Stroma superficial, globose, or sublgobose.
Stroma coloured—*H. coccineum* (Bull.)
H. deciduum B. & Br.
H. distillatum B. & Br.
Stroma black—*H. fragaria* Ces.

IV. *Clitoxylon.*—Pulvinate, more or less convex, not effused.
Stroma coloured—*H. hypomiltum* Mont.
H. vividum B. & Br.
H. quisquiliarum Mont.
H. discolor B. & Br.
H. Eterio B. & Br.
Stroma black—*H. chalybeum* B. & Br.
H. marginatum (Schw.) Berk.

V. *Placoxylon.*—Stroma broadly and widely effused.
Stroma coloured—*H. trugodes* B. & Br.
H. murcidum B. & Br.
H. anthochroum B. & Br.
H. subgilvum B. & Br.
H. chrysoconium B. & Br.
Stroma black—*H. oodes* B. & Br.
H. hypoleucum B. & Br.

All these Ceylon species are superficial. The distinction between *Eu-hypoxylon* as superficial, and *Placoxylon* as subsuperficial would appear to be invalid.

The accuracy of a classification based on the general shape of the stroma, depends upon the number of specimens available of each species. It is comparatively a simple matter to separate subglobose forms, such as *Hypoxylon coccineum*, but after that this method of classification fails, for the reason that, while a species normally developed may have a widely-effused stroma, it often produces depauperate stromata which are merely pulvinate. *Hypoxylon vividum* is classified as *Clitoxylon*, because the type specimen is poorly developed; it is really one of the largest effused species, single stromata attaining a length of about eight inches or more, while adjacent stromata may fuse into a more or less continuous sheet, several feet long. Again, *Hypoxylon distillatum* is not *Sphæroxylon*; the type consists of small stromata which are evidently poorly developed specimens of an effused species As far as the Ceylon species of *Hypoxylon* are concerned, it is not possible to classify them by the general shape of the stroma, except to divide off *Hypoxylon coccineum* and *Hypoxylon fragaria* from the remainder.

Nor is the division of the sections into stroma coloured, and stroma black, practicable in the case of herbarium specimens. *Hypoxylon marginatum* and *Hypoxylon chalybeum* are apparently always black, *i.e.*, black from the first development of the stroma. But the other Ceylon effused species have a coloured stroma in their early stages, and become black when old and weathered. The character is a useful one in the field, where it is possible to correlate immature stromata with black, weathered examples, but it evidently fails when applied to herbarium specimens. *Hypoxylon oodes*, for instance, is not black. Coloured specimens, treated with an alcoholic preservative, frequently turn black.

In the following list, the Ceylon species of *Hypoxylon* have been arranged in eight groups. It is not imagined that these groups will constitute valid subdivisions of the genus, nor that they will be other than locally, and temporarily, applicable, They may, however, serve to suggest some characters by which the genus may ultimately be subdivided.

The first group contains species which are subglobose. It includes *Hypoxylon coccineum* and *Hypoxylon fragaria*, the latter a doubtful *Hypoxylon*. The remaining divisions depend, as a rule, on a combination of characters.

One of the most useful characters, and one which is now generally recognized, is the " marginate " ostiolum, *i.e.*, an ostiolum seated in the centre of a flat disc, as in *Hypoxlon marginatum*. The genus can be divided into species which have marginate ostiola and species which have not.

A further basis of subdivision may be found in the fact that in some species the " perithecia " project, *i.e.*, the stroma is elevated after the manner of the apex of a perithecium over each perithecial cavity. On the other hand, in many species the surface of the stroma is even, or irregularly undulating, the undulations in the latter case bearing no relation to the underlying perithecial cavities. The former have been classed as " perithecial elevations distinct," the latter as " perithecial elevations absent." This division breaks down to some extent, owing to the fact that several species which have effused, even stromata may exhibit perithecial elevations towards the margin.

From the group with perithecial elevations distinct, there may be split off a series in which the apex of the perithecium is papillate, *e.g.*, *Hypoxylon quisquiliarum* Mont. In this group the perithecia may be separate or confluent.

Further subdivisions may be based on the mode of development of the different species, though it is very doubtful whether this will be applicable in herbarium work. In the most general mode of development of an effused *Hypoxylon* (Ceylon species being understood), the stroma first appears as a brightly coloured pruinose layer, not necessarily conidial, on the surface of the host. This is followed by the growth of a black layer beneath the coloured patch. The further development in thickness of the stroma takes place from below, beneath the coloured patch; hence the stroma is at first coloured and becomes black when weathered. In general, the perithecial elevations and ostiola are visible from an early stage, and the thin pruinose outer layer does not disappear until after the stroma is mature.

As a variant of the foregoing mode of development, some species, though developing in the same way at first, produce an even stroma on which no ostiola can be detected. The outer layer then separates in rather thick, brittle scales, disclosing the ostiola. It will, perhaps, not be possible to pick out, in the herbarium, species which develop in this manner, though in some instances the surface is marked with irregular ridges, which indicate the lines of separation of the scales.

Two (or three) Ceylon species develop in a manner which is, in a sense, the opposite of the foregoing. The stroma first appears as a white patch on the surface of the wood. The black carbonaceous tissue then begins to develop, not under the white layer, but on the exterior of it. It begins at different points, and forms black scutate patches on the white layer, and these extend laterally until they coalesce. The places at which the black tissue originates overlie the positions of the future perithecial cavities, which are laterally oval in the species hitherto determined. In the only species which has been collected in a mature condition, the mature stroma is pulvinate, and gives no indication of its mode of origin. The isolated black patches recall *Microthyriaceæ*.

A group which it may be possible to separate on the shape of the stroma is illustrated by *Hypoxylon chrysoconium*. In this group, the perithecia appear distinct, but they are united below by a thin carbonaceous layer. They are not seated upon this carbonaceous layer, but merge into, or are confluent with it. In *Hypoxylon chrysoconium*, the stroma is covered, except for the apices of the perithecia, by a pruinose coloured layer.

Many species of *Hypoxylon* yield a coloured extract with caustic potash. In some cases, however, the colour appears to vary with the age of the stroma.

Group 1.

Stroma subglobose.

Hypoxylon coccineum (Bull.). This species was collected by Thwaites, and sent to Berkeley with the fungi enumerated by Berkeley and Broome, but was not included in the Fungi of Ceylon. The specimens are now in Herb. Kew and Herb. Peradeniya. It is fairly common at Hakgala (5,600 ft.). Ceylon specimens are pulvinate, hemispherical, or more usually flattened, base circular or elongated, often confluent, up to 2 cm. diameter, or 3 × 1·5 cm., and 1 cm. high, brick-red, pruinose, rough with minute elevations, vermilion in the perithecial layer when young, internally purple-black, obscurely concentrically zoned. The perithecia are crowded, oval, 0·5–0·75 mm. high, 0·4–0·5 mm. diameter ; ostiola not prominent. The asci are clavate, with a long tapering pedicel, 70–85 × 7 μ, with spores obliquely uniseriate. The spores are fuliginous to dark brown, cymbiform, ends obtuse, 7–8 × 3·5 μ.

Hypoxylon fragaria Ces. The position of this species is uncertain. A specimen in Herb. Kew from Cesati is pulvinate, pruinose at first, olive (?), obscurely tuberculate, with perithecial elevations 0·6–1 mm. diameter, and the ostiola not evident or slightly papillate. The stroma is now hollow, except for the perithecia ; the latter are in one layer, united to a thick outer crust, 0·5 mm. thick. The perithecia are ovoid, or angled by mutual pressure, and measure, externally, up to 3 mm. in depth and 2 mm. in diameter. The perithecial wall is 0·2 mm. thick. The spores are black-brown, narrow-cymbiform or oblong-oval, ends obtuse, 50–52 × 12–17 μ. Cesati's figure shows much more prominent ostiola and a more tuberculate stroma. He stated that the stroma was black internally, almost entirely filled by the perithecia, and that there were no traces of asci, none of which statements agrees with the specimen. He gave the spores, 24–28 × 14–16 μ ; Cooke in Grevillea, XI., p. 123, gave 55–60 × 12 μ. Its massive perithecia recall those of *Nummularia porosa*, but its spores are very different. It would appear to approach *Ustulina macrosperma* (Mont.) Sacc.

GROUP 2.

Perithecial elevations distinct : ostiola marginate.

Hypoxylon marginatum (Schw.). I follow Berkeley in his identification of the Ceylon forms under this name. Generally, they consist of thin, flat stromata, black, with well-marked perithecial elevations ("perithecia projecting"), and ostiola seated on a disc. Of the collections enumerated by Berkeley and Broome, the parts now in the Peradeniya herbarium are as follows: Thwaites 294 has conical ostiola, not marginate; it is not *H. marginatum*, but as it is immature, nothing further can be said of it. Thwaites 296 contains two forms; one of them has a glabrous, brittle stroma, up to 0·6 mm. thick, with perithecial elevations 0·4 mm. diameter, discs 0·2 mm. diameter, perithecial cavity globose, 0·3–0·4 mm. diameter, spores 6 × 3 μ, and is apparently *H. marginatum;* the other does not show perithecial elevations, has a stroma 0·5 mm. thick, disc 0·2 mm. diameter, spores 5–7 × 3 μ, and is *Hypoxylon punctatum*. No. 297 also contains two forms. 297A has perithecial elevations 0·6–0·8 mm. diameter, slightly prominent, discs 0·3 mm. diameter, stroma 0·75 mm. thick, perithecial cavity globose, 0·5 mm. diameter, spores 7–8 × 4 μ; 297B has the perithecial elevations prominent, the perithecia projecting one-third of their height, up to 0·8 mm. diameter, stroma 1 mm. thick, perithecial cavity 0·7 mm. diameter, disc 0·2 mm. diameter, spores 7–8 × 3–4 μ; both these are *H. marginatum*. Thwaites 1082 is the species named *Hypoxylon olivaceum* below; it differs in structure from the *marginatum* series.

Spores of *H. marginatum* are usually thin-walled, pale fuliginous to pale brown; the stroma is brittle and does not yield an extract with caustic potash.

Hypoxylon chalybeum B. & Br. The Ceylon specimen in Herb. Kew has perithecia about 0·8 mm. diameter, aggregated in pulvinate masses. The disc is about 0·4 mm. diameter, with a rather sharp raised edge, and a small conical ostiolum. The perithecia are black, rough, with traces of mycelium in the furrows between them. They scarcely warrant the description "nitidissimis." The spores are broadly cymbiform, 9–11 × 5 μ. Caustic potash gives a yellow-green extract.

A recent gathering from Hakgala (No. 4601) has perithecia 0·75 mm. diameter, confluent in flattened-pulvinate stromata about 5 mm. diameter, or larger by confluence ; the disc is up to 0·5 mm. diameter. The stromata have a stout carbonaceous basal layer, which does not extend beyond the perithecia, and mycelium between the apices of the perithecia. It yields a strong yellow-green extract with caustic potash. In No. 4587, also from Hakgala, the perithecia are smaller, 0·5 mm. diameter, with discs, 0·25 mm. diameter. They are partly covered by purple-brown mycelium, and are scattered or confluent on a thin stroma, which in some places is thin and carbonaceous, and in others consists merely of a single layer of mycelium overlying and blackening the wood.

The presence of purple-brown mycelium over the stroma would appear to distinguish this species from the numerous forms of *Hypoxylon marginatum.* Baker, Fungi Malayana, No. 143, det. Rehm as *Hypoxylon marginatum* (Schw.) Berk. is this species.

A series of specimens, probably older examples of *H. chalybeum*, has been collected, chiefly at Hakgala, which are remarkable for the highly varnished condition they assume on treatment with alcoholic mercuric chloride. The perithecia are large and globose, up to 1·5 mm. diameter, either confluent in groups, or isolated, seated on a thin carbonaceous stroma which extends for several inches. Isolated perithecia frequently appear to be embedded in, or surrounded by, an upward development of the stroma. The spores are rather pale brown, and measure 8 × 3·5–5 μ. Caustic potash gives a green extract.

GROUP 3.

Stroma at first covered by a coloured crust which cracks and scales off, leaving the surface somewhat ridged and lacunose ; ostiola marginate ; perithecial elevations wanting.

As far as my observations show, the species of this group differ from those of Group 2 in their mode of development. In the latter group, the stroma has no outer deciduous coat. In the present series, the stroma is at first even, and the ostiola are not visible. The surface then cracks, and a fairly thick, crustaceous layer separates in scales, leaving the stroma slightly lacunose and ridged. The process is again quite different from the usual course in coloured stromata, in which the ostiola, as a rule, are always evident, and the thin, outer, pruinose or tomentose, coloured coat weathers off, leaving the stroma black.

Hypoxylon olivaceum n. sp. Stroma greenish-olive to olive-brown at first, then greenish-black, flattened-pulvinate, margin rounded, up to 2 to 3 cm. long, 1 cm. broad, 2 mm. thick. Outer layer smooth, cracking and scaling off, leaving the surface even, or slightly lacunose and ridged. Ostiola minute, conical, on discs up to 0·2 mm. diameter. Perithecia angular-cylindric, up to 0·8 mm. high, 0·3–0·4 mm. diameter, crowded. Spores pale fuliginous to brown, narrow cymbiform, ends rounded, 10–13 × 3–4 μ. Alcohol gives in some cases a green extract. Caustic potash (after alcohol) gives a dirty purple extract. Type, No. 4532 in Herb. Peradeniya. Frequent at Peradeniya on mango. Specimens, Thwaites 1082, were included by Berkeley and Broome under *Hypoxylon marginatum.*

Hypoxylon punctatum n. sp. Initial layer plum-coloured or maroon or chocolate-brown. Stroma at first of the same colour, minutely pruinose, the outer layer sometimes wrinkled, finally black, flat, effused, even, or with a few obscure perithecial elevations towards the margin, up to 0·5 mm. thick, margin rounded. Ostiola at first not evident, ultimately scattered, minute, conical, each seated on a sunken disc, 0·2 mm. diameter. Perithecia globose, 0·4 mm. diameter, or cylindric, 0·4 × 0·2 mm.; spores subcymbiform, rather pale-brown, 5–7 × 2–4 μ. Alcohol and caustic potash extracts yellow-green; with very young stromata the potash extract is vivid green. Type, No. 4465 in Herb. Peradeniya. In this species, the outer layer disappears only over the ostiola.

Hypoxylon denudatum n. sp. Stromata flattened pulvinate with a rounded margin, small, circular or elongated, up to

2 × 1 cm., and 1 mm. thick. At first red-brown or ferruginous, smooth, even, the outer coat disappearing, leaving the surface papillate with minute, broadly conical ostiola, each seated on a circular disc, 0·2 mm. diameter. Perithecia oval, up to 0·6 mm. deep, 0·4 mm. diameter. Spores narrow-oval or subcymbiform, ends obtuse, pale fuliginous, 8–10 × 3–3·5 μ. Alcohol extract red-brown, potash extract red-brown. Type, No. 3875 in Herb. Peradeniya ; Gangaruwa, December, 1913.

Hypoxylon distillatum B. & Br. The cotype in Herb. Peradeniya is immature. Berkeley and Broome did not give the dimensions of the spores, but Cooke (Grevillea, XI., p. 122) stated that they measured 10–11 × 4–5 μ. The former authors described the stroma as coffee-coloured, but from the herbarium specimens it would appear to have been purple-red or red-brown when fresh.

The stromata are pulvinate, usually thinning out gradually at the margin. The outer layer is even, or has a few obscure elevations, and is cracked, but the scales have not separated. Here and there can be seen papillate ostiola sunk in a deep pit, The stroma is up to 1·5 mm. thick, with a stout basal layer. the perithecia being cylindric or wedge-shaped, up to 1 mm. high, and 0·4 mm. diam. Caustic potash (after alcohol) gives a muddy green extract.

This evidently belongs to the same group as *Hypoxylon olivaceum*, but as specimens have not been collected recently, it is not possible to say to what degree the peculiarities of the stroma are to be attributed to immaturity.

Group 4.

Perithecial elevations absent : ostiola not marginate.

Hypoxylon vividum B. & Br. Stroma cinnabar when fresh, fading to yellowish-red, up to 20 cm. long, 6 cm. wide, and 3 mm. thick, flattened, with a rounded margin, pruinose, perithecial elevations scarcely evident, except here and there towards the margin. Ostiola obscurely papillate, papilla 0·2 mm. diameter, opening large. Surface sometimes feebly ridged. Stroma soft, black internally, perithecial walls appearing yellow to orange when mounted. Basal layer stout; perithecial cavities angular-cylindric, up to 1·5 mm. high, 0·2–0·4 mm. diameter. Asci, sporiferous part, 80–100 × 8–9 μ. Spores cymbiform, ends obtuse, black-brown, 13–15 × 7 μ. Alcohol extract red-brown: potash extract vivid red. The soft stroma is frequently hollowed out by beetle larvæ.

Hypoxylon discolor B. & Br. Stromata up to 2 mm. diameter, scattered or crowded, pulvinate, subhemispherical, or flattened pulvinate, with a smooth, shining, cinereous outer coat which scales off; perithecial elevations wanting. Ostiola scattered, slightly projecting. Internally yellow, perithecia black. Asci cylindric, 70–90 × 8–12 μ. Paraphyses filiform. Spores black-brown, broadly oval, slightly inequilateral, 8–13 × 5–7 μ. No colour with caustic potash.

Hypoxylon pelliculosum n. sp. Initial stroma byssoid, red-brown with an orange margin, the extreme edge white (? *Corticium peroxydatum* B. & Br.), effused, becoming clay-coloured, or pale red-brown, with a glabrous, shelly, outer coat which cracks and falls off on drying; beneath the outer coat, red-brown and pulverulent at first, becoming black. Mature stromata pulvinate, up to 4 mm. diameter and 2 mm. high, or larger by confluence; ostiola scattered, black, slightly conical, penetrating the outer layer; stromata internally yellow-brown, rather loose. Perithecia 0·3 mm. diameter, globose, wall yellow, translucent except at the black apex. Asci cylindric, 120 × 10 μ, spores obliquely uniseriate. Spores black-brown, broadly cymbiform, ends rounded, 10–12 × 6–8 μ, a few subglobose. Alcohol extract yellow-brown; caustic potash extract vivid brownish-red. On dead branches, Peradeniya, October, 1914; No. 4227 in Herb. Peradeniya.

Immature stromata of this species, in their initial stage, frequently extend over a length of ten centimetres, but the only mature stromata available are small. Attempts to develop the mature form from large specimens in the byssoid initial stage have been only partly successful; in the laboratory they readily develop the shelly outer coat, but only become pulvinate here and there in small patches and do not produce perithecia.

Hypoxylon hypomiltum (Mont.). Two Thwaites's collections were assigned to this species by Berkeley and Broome. Thwaites 1088 has flattened-pulvinate, even stromata, irregularly circular, up to 1·5 × 1 cm., furfuraceous, probably red when fresh. The ostiola are punctiform, black, here and there slightly papillate. The stromata are about 0·3 mm. thick, with perithecial cavities, oval, about 0·2 mm. diameter, almost the height of the stroma, there being hardly any basal layer. The perithecial walls are black, the tissue between the apices of the perithecia red. The spores are cymbiform, ends rounded, pale blackish-brown, 7–9 × 4 μ. The alcohol extract is red-brown, becoming slightly purplish with caustic potash. Thwaites 1091 is the same, but has spores 8–10 × 5 μ. This species has not been recently collected in Ceylon.

Hypoxylon vestitum n. sp. Stroma effused, several centimetres long and broad, about 1 mm. thick, almost plane, margin rounded, surface slightly irregularly undulating. At first with a byssoid or farinaceous, pale ochraceous, outer coat which weathers off, leaving the stroma purple-grey, finally black. Individual perithecial elevations lacking. Ostiola scattered, conical, minute. Perithecial cavities oval or cylindric, up to 0·6 mm. high, 0·4 mm. diameter. Spores black-brown, cymbiform, 9–12 × 4 μ. No extract with alcohol or caustic potash. On a tea stem, Diyanila Kæle, March, 1906 ; No. 4923 in Herb. Peradeniya.

Hypoxylon angustum n. sp. Stromata forming irregular patches, up to 1·5 cm. long, 1 cm. broad, flattened-effused, usually thinning out at the margin, irregularly undulating, perithecial elevations absent, purple-grey, then black, carbonaceous, thin, 0·4 mm. thick, with scarcely any basal layer : ostiola scattered, minute, obtusely conical, not marginate. Perithecia subglobose, or laterally oval, 0·3 mm. high, 0·3–0·5 mm. diameter. Spores oval to cymbiform, sometimes slightly curved, ends obtuse, black-brown, with a large central gutta, 22–28 × 8–9 μ. No extract with potash. On a dead tree trunk, Peradeniya, January, 1917; No. 6103 in Herb. Peradeniya.

GROUP 5.

Perithecial elevations distinct: ostiola not marginate.

Hypoxylon subgilvum B. & Br. Reddish-purple (plum-coloured), cinnabar beneath the outer coat; young specimens ferruginous. Stroma effused, thin (0·5–1 mm. thick), pruinose; perithecial elevations variable, 0·2–0·5 mm. diameter. Asci long-pedicelled, about 100 × 6 μ. Spores oval to cymbiform, ends rounded, blackish-brown, 8–12 × 4–5 μ. Caustic potash gives a vivid red extract in fresh specimens. The type specimens are now ferruginous and yield a reddish-yellow extract with potash. The colours given above are those of fresh specimens which appear to match the type.

Hypoxylon murcidum B. & Br. Widely effused, several centimetres long and broad, usually thinning to the margin, up to 1·5 mm. thick, brittle, pruinose, apparently purple-red when fresh, available specimens chiefly black, basal layer stout. Perithecial elevations slight, up to 0·4 mm. diameter, ostiola not evident; perithecia angular-cylindric, up to 0·6 mm. high, 0·35 mm. diameter. Spores subcymbiform, black-brown, 11-13 × 5-6 μ. Extract with caustic potash, dirty green. Not collected recently.

Hypoxylon carneum n. sp. Stromata pulvinate, circular, up to 4 mm. diameter, or confluent in patches up to 1 cm. long, tomentose, pinkish or reddish-white; margin white, byssoid, or wanting. Perithecial elevations prominent, rounded, about 0·2 mm. diameter; ostiola not evident. Perithecial wall black, carbonaceous; substance of stroma composed of pale red, or purple-red hyphæ between the perithecia, compact and black below. Asci cylindric, 80–90 × 7–8 μ. Spores oval, brown, 8–10 × 4 μ. Paraphyses linear. On dead *Cinnamomum Camphora*, Hakgala, September, 1908; No. 2855 in Herb. Peradeniya.

Hypoxylon oodes B. & Br. Perithecia 0·6–0·9 mm. diameter, scattered, or united basally into a stroma, usually flat, sometimes forming pulvinate masses. Perithecia clothed with a thin, purple-grey, or grey, tomentose layer ; ostiolum naked, black, scarcely elevated. Perithecial wall soft (not carbonaceous), with a reddish fracture. Asci 110–130 × 6–7 μ, long-pedicelled. Spores blackish-brown, subcymbiform, 11–13 × 5–7 μ. Caustic potash gives a deep red-brown extract.

The type has perithecia 0·6 mm. diameter : in recent collections they vary from 0·7 mm. to 0·9 mm. On preserved specimens the tomentose layer becomes reddish. Berkeley and Broome stated that the ostiolum was papillæform, surrounded by a small depressed ring, and Theissen (Ann. Myc., VI., p. 538), regarded it as related to the *marginatum* series. The ostiolum is not marginate, *i.e.*, on a disc, and Berkeley and Broome's description was probably based on the fact that the outer layer of tomentum terminates just below the ostiolum, leaving a naked, black apical area.

Hypoxylon anthochroum B. & Br. Stromata pulvinate, about 4 mm. diameter, often coalescing, sometimes plane ; purple-red or maroon, black internally, pruinose, soft when fresh, not carbonaceous ; perithecial elevations prominent, 0·3–0·4 mm. diameter, ostiola not projecting ; perithecial cavity oval, about 0·4 × 0·2 mm. Spores black-brown, broadly cymbiform, often oblique, ends rounded, 8–14 × 5–7 μ. The extract with potash varies ; on fresh specimens it is greenish yellow to brownish-yellow, on old herbarium specimens yellow-green to muddy-green. Common at Peradeniya on branches of *Poinciana regia*.

Spore measurements on the type specimens gave 13–14 × 6–7, and 10–14 × 5–7. In recent collections they are 10–12 × 5–7 (extruded spores), and 8–12 × 5–6. In two collections which appear to be this species, but in which the stromata are chiefly flat, the spores are 7–9 × 4–5 μ, and 8–9 × 5 μ respectively.

Hypoxylon cupricolor n. sp. Stromata flattened pulvinate, about 5 mm. long, 2–3 mm. broad, usually confluent for several centimetres, about 0·5 mm. thick, copper coloured to red-brown, at first pruinose ; perithecial elevations slightly prominent, about 0·4 mm. diameter ; ostiola minute, obtusely conical; perithecial cavity oval, 0·3–0·4 × 0·2–0·3 mm. Spores broadly cymbiform, sometimes oblique, blackish-brown, 6–9 × 3–4 μ. No extract with caustic potash. On dead branches, Peradeniya, December, 1913; No. 4101 in Herb. Peradeniya. Near *H. anthochroum*, but ostiola projecting.

Hypoxylon trugodes B. & Br. Stromata dark purple-red, extending for several centimetres, consisting of separable perithecia, either globose, 0·25 mm. diameter, or cylindric, 0·25–0·6 mm. high, 0·2–0·3 mm. diameter, in continuous or discontinuous patches, with an effused, purple-red, furfuraceous, barren margin, usually extending far beyond the perithecia. Perithecia furfuraceous, ostiolum papillate or obtusely conical; wall at first soft, becoming brittle; inner layer of perithecial wall yellow-brown, with fuscous longitudinal hyphæ; between the perithecia orange and loose on fracture, especially near the base. Spores broadly cymbiform, or oval and inequilateral, 8–12 × 4–7 μ. Alcohol extract yellow-brown, turning red-brown with caustic potash.

In the type specimen, the perithecia are cylindric or obconoid, 0·4–0·6 mm. high, and 0·3 mm. diameter, and the spores measure 8–9 × 4 μ; the perithecial wall is soft and the perithecia separate readily. In recent examples, on bamboo, the perithecia are globose, 0·25 mm. diameter, or cylindric, 0·2 mm. diameter, 0·25 mm. high, and the spores measure 10–12 × 5–7 μ; the perithecial wall is more brittle, and the perithecia are more firmly attached to one another, though still separable.

GROUP 6.

Apex of perithecium papillate.

Hypoxylon quisquiliarum Mont. The Ceylon specimen named by Berkeley and Broome has globose perithecia, 0·75 mm. diameter, with a broad cylindrical neck, 0·2 mm. diameter, and a punctiform ostiolum; they are isolated, or united in small groups of two to four. The perithecia are rugose, clothed above with coarse yellow granules. The spores are black-brown, broadly cymbiform, ends usually obtuse, 25–32 × 13–14 μ.

Hypoxylon perforatum Schw. Specimens in Herb. Peradeniya corresponding to those named by Berkeley and Broome have stromata irregularly pulvinate, about 4 mm. diameter, or extended and flat, in the latter case continuous or interrupted, with perithecia about 0·6 mm. diameter, strongly projecting. They are furfuraceous, apparently some shade of red when fresh. The apex of the perithecium is papillate, with a punctiform ostiolum. The perithecial cavity is globose, up to 0·4 mm. diameter. The asci are long-pedicelled, up to 110 μ long, and the spores broadly cymbiform, ends obtuse, 12–15 × 7–8 μ. The alcohol extract is reddish-brown ; caustic potash extract the same.

Group 7.

Perithecia scattered or clustered, confluent with a thin carbonaceous stroma.

Hypoxylon chrysoconium B. &. Br. Stromata about 5 mm. diameter, feebly pulvinate, at first byssoid, pulverulent when old, yellow, orange, or reddish-orange with a white edge. Perithecia black, flattened globose, 0·4 mm. high, 0·5 mm. diameter, scattered or clustered, merging into (not seated on) a thin black stroma, the whole, except the apices of the perithecia, hidden by the outer, coloured, mycelial layer. Ostiola minute, conical. Asci cylindric, 90–110 × 7–8 μ, sporiferous part, 70–80 μ, pedicel tapering. Spores elliptic to narrow oval, blackish-brown, 9–13 × 5–6 μ. No extract with caustic potash..

A fairly common species, at first sight appearing quite distinct from *Hypoxylon*, and resembling a group of scattered perithecia embedded in mycelium.

Hypoxylon hypoleucum (B. & Br.) Cooke. This species was described by Berkeley and Broome as *Sphæria* (*Confluentes*) *hypoleuca*. The perithecia are hemispherical, 0·7 mm. diameter, black-brown, pruinose, brittle, scattered or confluent in small groups, merging into a thin, carbonaceous stroma ; the ostiola are minute and conical. In the herbarium specimen, there are slight remains of pale-coloured mycelium between the perithecia. The spores are oval or subcymbiform, ends obtuse, black-brown, 8–11 × 4–5 μ.

Berkeley and Broome stated that the perithecia are "in mycelio arcte adnato parco innatis," which would bring this species near the foregoing, but in the herbarium specimens, which alone are available, this is scarcely a marked feature, and at first sight the stroma appears black and naked. They gave the measurement of the spores as varying from 7·5–8·5, or 5-6 by 3 μ. It is not a good *Hypoxylon*.

GROUP 8.

This group includes two (or three) species whose development is exactly the reverse of that of the usual *Hypoxylon* with a coloured stroma. In the latter, a coloured pruinose layer first appears on the wood or bark, and the stroma, black or coloured, develops beneath it. In the present group, a white mycelial layer first arises, and the black stroma is formed from the uppermost part of this. The formation of the stroma thus takes place from above downwards. In the earlier stages, the stroma may consist of a black crust, overlying a white layer which extends beyond its margin, or of scattered black circular patches, the apices of the future perithecia, similarly situated. The white marginal tissue is continuous with the tissue beneath the developing perithecia, not over them as in *Hypoxylon chrysoconium*.

The following species fall in this group.

Hypoxylon epixanthum (B. & Br.), comb. nov. This was described by Berkeley and Broome as *Sphæria* (*Confluentes*) *epixantha*, "Mycelio sulphureo; peritheciis confluentibus depressis materie nigra alligatis; ostiolo candido medio stictico." They did not describe the spores. The herbarium specimens are immature, but they agree, in the details which are ascertainable, with specimens recently collected. The stroma is at first white and byssoid, subsequently developing a black, carbonaceous, superficial layer and forming irregular, extended, black patches with a white margin. These patches are very thin, glabrous, undulating rather than tuberculate, with rounded, isolated, perithecial elevations about 0·4 mm. diameter. These thin stromata are white internally. The fully-developed stroma is black, carbonaceous, pulvinate, up to 1 mm. thick, usually with a rounded margin, glabrous, with slight perithecial elevations. The ostiola are minute, conical, each situated in a depressed area, about 0·1 mm. diameter, formed by the scaling off of the outer crust over the ostiolum. The perithecia vary from laterally oval, 1·5 mm. diameter, 0·5 mm. high, to subcylindric, 0·4 mm. diameter, 0·6 mm. high. The asci are up to 130 × 6 μ. with a long pedicel, the sporiferous part being 90–96 μ. long. The spores are cymbiform, ends rounded, black-brown, 11–15 × 5–6 μ. Cooke (Grevillea XV., p. 81) listed this species as *Byssosphæria* (*Rosellinia*) *epixantha*.

Sphæria (Confluentes) albofulta B. & Br. This is another species, or collection of species, of this group. The type in Herb. Kew is marked by Berkeley, " *Sph.* (*Confluentes*) *epileuca* B. &. Br. *Sph. albofulta* B. & Br." ; and Cooke, in Grevillea, XV., p. 81, referred to it as *Byssosphæria* (*Rosellinia*) *epileuca*. There are apparently two species in the type, but, unfortunately, both are immature. In one of them, the stroma is white, pulverulent, bearing developing black patches which are broadly conical with an expanded base (scutate), at first distinct, becoming confluent, up to 1·5 mm. diameter, often radially corrugated, glabrous, brittle ; the perithecial cavity is laterally oval, up to 1·2 mm. diameter, and 0·5 mm. high. The other species is similar, but the mycelial stroma is grey and thinner, and the developing black patches over the perithecia are 0·3 mm. diameter, scattered, with a papillate ostiolum.

Coniophora Broomeiana Mass. is an immature *Hypoxylon* of this group, probably identical with the second species in *Sphæria albofulta*.

9. *Dubiæ et excludendæ.*

Hypoxylon deciduum B. & Br. This species has been collected recently on several occasions, but the available examples are not in a condition which would decide its position. The stromata occur (? always) on decaying palm fronds. They are wholly superficial, and readily separable from the substratum, at first rufous-brown, pruinose, surrounded by a thin, brown hypothallus, and sometimes also by a weft of loose mycelium ; when old they become smooth, and finally black and slightly tuberculate. The stromata are pulvinate, or flattened pulvinate, up to 6 mm. diameter and 2 mm. high, with a rounded margin, and the ostiola are scattered and slightly projecting. Internally they are brown, with a parenchymatous upper layer about 0·4 mm. thick: the perithecial walls are also parenchymatous, with an inner layer of parallel cells. The tissue between the perithecia and at the base of the stroma is loosely fibrillose, and the perithecia readily separate from one another when the stroma is sectioned.

The perithecia are crowded, sometimes in two layers, deeply sunk in the stroma, thick-walled, oval, about 0·5 mm. deep and 0·25 mm. diameter, with a long cylindrical neck, up to 0·4 mm. long, penetrating the cortex of the stroma. In one recent collection (2881) the perithecia contain hyaline, elliptic spores, 6–9 × 3 μ. In another (3850), they are filled with stout septate paraphyses (?), about 5 μ diameter, tapering upwards. I have not been able to find asci, nor to discover how the spores are produced. Berkeley and Broome did not describe the spores. Cooke in Grevillea, XI., p. 122, stated that the spores were 15–18 × 3 μ and passed it as *Hypoxylon*.

Hypoxylon umbrinellum B. & Br. This species was said by Berkeley and Broome to have uniseptate spores, and in Saccardo, I., 729, it was listed, with a query, as *Amphisphæria*. The perithecia, in the cotype in Herb. Peradeniya, are quite separate from one another, but crowded on a slight basal mycelium. They are conoid, 0·3 mm. diameter, apex papillate, pruinose, dark brown (dry) ; the ostiolum is punctiform, and furnished with periphyses. The spores are elliptic to fusoid, ends obtuse, one-septate, not constricted, pale brown, with a striate, verrucose wall, 11–14 × 5 μ. The species is evidently *Nectria* (*Cosmospora*), and has been published as *Nectria umbrinella* (B. & Br.) in Ann. Perad., VI., p. 344.

Hypoxylon niphidium B. & Br. This was described as having hyaline, three-septate spores, and was included in Saccardo under *Melogramma*. Berlese, Icones Fungorum I., p. 50, stated that the original specimens were sterile.

In the cotype in Herb. Peradeniya, the stromata are circular, up to 4 mm. diameter, pulvinate or flattened pulvinate, minutely tomentose, with prominent ostiola. They were apparently pale yellow. The tissue of the stroma is white and rather loose. The perithecia are situated at different depths, and have thick, yellow walls. The perithecial cavity is oval, about 0·35 × 0·25 mm., and the neck is up to 1·5 mm. long, totally embedded. The asci are 6–8 μ in diameter, with uniseriate spores. The spores are hyaline, fusoid, spinulose, three-septate, slightly constricted, ends apiculate or rounded, 30–34 × 6–8 μ; sometimes one cell is inflated.

The structure of the stroma is that of *Hypocrea*. The spores resemble those of a *Hypomyces*, but are three-septate. The species agrees very well with *Broomella*, though the spores have only a short apiculus, instead of the long filament figured by Broome for *Broomella Vitalbæ* (B. & Br.). It was transferred to *Broomella* by Cooke, in Grevillea, XII., p. 105.

Hypoxylon rubiginosum (Fr.) The specimens under this name in Herb. Peradeniya, Thwaites 570, are the same as those assigned by Berkeley and Broome to *H. perforatum* (Schw).

Hypoxylon rubricosum (Mont.). The specimens in Herb. Peradeniya under this name, Thwaites 260, do not appear to be related to *Hypoxylon*. One large flat piece, about 8 × 2 cms., is *Punctularia atropurpurascens* (B. & Br.) Petch. Others are irregularly convoluted, pulvinate stromata, roughly oval, about 6 × 4 mm., scattered or crowded; they bear hyaline, oval conidia, 5–7 × 2 μ, in the cavities of the stroma.

Hypoxylon ceramichroum B. & Br. This was transferred by Cooke to *Glaziella*. As has been previously recorded, it is a *Hypocrella* (Ann. Perad., VII., p. 214).

Daldinia.

Daldinia concentrica Ces. & de Not. This was recorded for Ceylon by Berkeley in Hooker's London Jour. Bot., VI., p. 514 (Gardner 85), and by Berkeley and Broome in Fungi of Ceylon, No. 1055 (Thwaites 187). It is abundant at Peradeniya and in the low-country on dead logs of all kinds of dicotyledonous trees. The stromata are up to 7 cm. in diameter and 3 cm. high, plum-coloured or copper-coloured; the asci, *pars sporifera,* measure 70–85 × 8–10 μ, with a tapering pedicel, up to 170 × 2–3 μ; and the ascospores, 11–16 × 6–9 μ. It is doubtful whether this is identical with the European species. The stromata are more spongy than European specimens of *Daldinia concentrica*, the initial colour is different, and though the stromata become black when old they do not appear varnished.

Nummularia.

Nummularia pithodes (B. & Br.) Petch. This was described by Berkeley and Broome as *Diatrype pithodes:* it was redescribed in Ann. Perad., IV., p. 436. A common species in up-country jungles on miscellaneous trees, and elsewhere on coconut, *Hevea*, &c. It may be noted that Cesati recorded *Hypoxylon pithodes* Berk. from Rambode (Borneo), and *Hypoxylon anthracodes* Mont., Sarawak, ad Rambode. It is possible that this name may occur in Sarawak and Borneo, but Ramboda is one of the localities in which Beccari collected in Ceylon.

Nummularia porosa n. sp. Effused, surface at first black and smooth, the outer layer separating in large flakes leaving the surface pitted with irregular pores; ostiola not projecting. Up to 4 mm. thick; outer crust up to 1 mm. thick, black, breaking with a fluted fracture; perithecial layer dark brown. Perithecia large, subglobose, distorted by mutual pressure, up to 2·5 mm. diameter, with a conical ostiolum which is totally embedded in the crust. Perithecia sometimes partly free below. Spores narrow-oval, symmetrical, ends rounded, continuous, pale fuscous, 12–16 × 5–6 μ. On decaying trunk of *Artocarpus integrifolia*, Peradeniya, December, 1913 ; No. 3934 in Herb. Peradeniya.

Nummularia plana n. sp. Stroma black, or greenish-black, up to 3 cm. long, 1 cm. broad, flat, about 1 mm. thick, plane, with scattered, minute, conical ostiola ; margin subvertical. Perithecia crowded, cylindric, 0·5 mm. high, 0·1 mm. diameter. Asci 100 × 8 μ, eight-spored, spores obliquely uniseriate. Paraphyses linear, 1·5 μ diameter. Spores black-brown, opaque, oval, 10–12 × 5–6 μ. On a dead branch, Hakgala, January, 1914 ; No. 3932 in Herb. Peradeniya.

Pleomelogramma.

Pleomelogramma rugosa n. sp. Stromata developing in or on the outer layers of the wood, splitting off the bark and wood and becoming superficial, up to 10 cm. long, 4 cm. wide, 1·5 cm. thick, irregularly pulvinate, black, carbonaceous externally, rough with close-set, conical, cylindric, or pulvinate ostiola up to 0·3 mm. diameter and 0·7 mm. high ; internally dark brown or chocolate-brown, radially or vertically fibrillose, soft and friable ; cracking irregularly, the exposed internal tissue in the fissures becoming black, radially and transversely corrugated. Perithecia embedded in the stroma near the exterior, subglobose, 1 mm. diameter, or vertically oval, 1·2 × 0·6 mm. ; perithecial wall black, brittle, 16–20 μ thick. Asci, *pars sporifera*, 105–112 × 8–10 μ, cylindric ; paraphyses numerous, linear ; spores narrow-oval or oblong-oval, ends rounded, greenish-hyaline, three-septate, with a longitudinal septum in one or both the median loculi, 16–24 × 7–8 μ. On a dead branch, Hakgala, March, 1922 ; No. 6374 in Herb. Peradeniya.

When old the stroma readily breaks into fragments along the fissures. In general structure it appears to resemble *Hypoxylon congestum*, but the internal colour and texture are different, and it lacks the continuous thick crust which underlies or unites the projecting ostiola in the latter species.

A Note on Diplodiella.

BY

T. PETCH, B.A., B.Sc.

In the Annals of the Royal Botanic Gardens, Peradeniya, Vol. IV., pp. 445–465, the writer published a paper "On *Lasiodiplodia*," in which it was shown that the supposed distinctions between several of the genera of the *Sphærioidaceae Phæodidymæ* are not constant, and that reliance on them has led to much confusion. Perhaps the most notable instance of that confusion, which has yet been recorded, is that of the species chiefly considered in the paper referred to, viz., *Botryodiplodia Theobromæ* Pat., the common *Diplodia* on cacao, which has been described by different mycologists as *Diplodia*, *Botryodiplodia*, *Lasiodiplodia*, and *Chætodiplodia*, and that quite accurately, according to the specimens examined by each.

Botryodiplodia Theobromæ may occur in the form of scattered pycnidia, *i.e.*, as a simple *Diplodia ;* and on cacao pods in a damp atmosphere these pycnidia may bear projecting hyphæ, in which case it is a *Chætodiplodia.* Or the pycnidia may be grouped in a stroma, *i.e.*, as *Botryodiplodia ;* and this stroma may be covered with a weft of hyphæ, when it becomes *Lasiodiplodia.*

Observations which have since been made show that the above does not exhaust the possibilities of *Botryodiplodia Theobromæ*, though it must be pointed out that whereas the forms already mentioned occur under natural conditions, those now recorded are rather of the nature of abnormalities.

In the course of an investigation of a root disease of tea, caused by a *Diplodia* which is morphologically indistinguishable from the cacao *Diplodia*, a lateral root of tea, about one and a half centimetres in diameter, which was attacked by that fungus, was placed in a closed glass jar—and forgotten. Some weeks later, it was observed that this root bore numerous, black, projecting points, which appeared to be projecting

[Annals of the Royal Botanic Gardens, Peradeniya, Vol. VIII., May, 1924.]

ostiola, but on examination they proved to be *Diplodia* pycnidia (fig. 1).

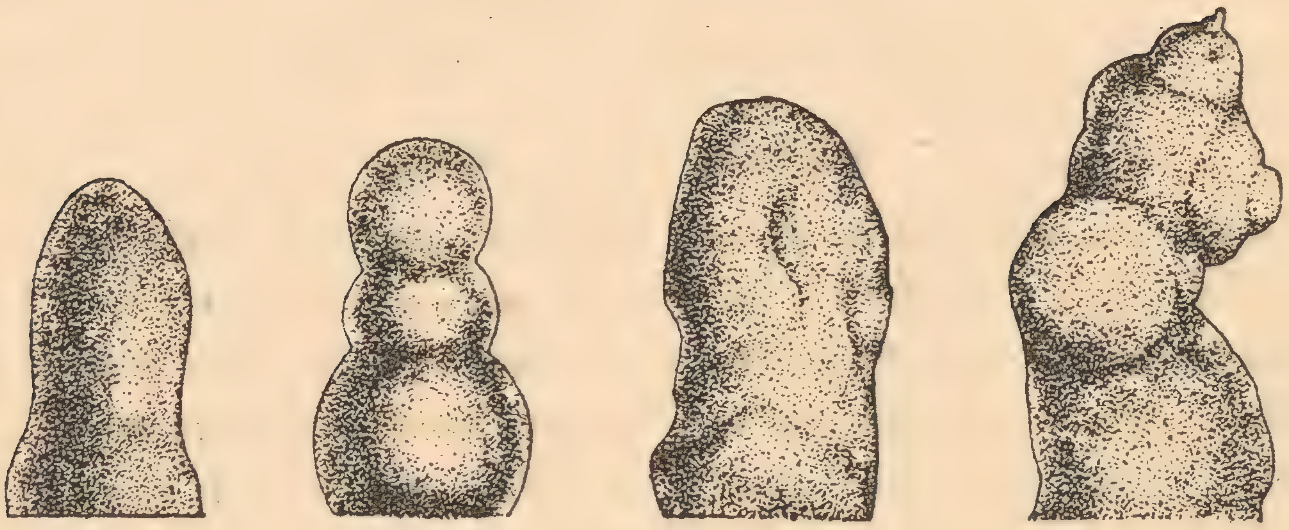

Fig. 1.—Pycnidia, × 30.

These pycnidia are almost superficial, only slightly immersed at the base. They are irregularly cylindric, 0·6–0·9 mm. high, and 0·3–0·45 mm. diameter. The apex is usually obtuse and rounded, with a central ostiolum. Some pycnidia are attenuated towards the middle and expand again towards the apex: others are constricted somewhat abruptly at intervals, and resemble a series of superposed globose pycnidia; while others are irregularly vertically furrowed. The cavity of the pycnidium (fig. 2) is cylindric, and the wall is fleshy, not carbonaceous, with a thick outer layer, up to 0·1 mm. broad, rather loose in texture, and a thin, compact inner layer. The specimens are immature, and the majority of the spores are about 16 × 8 μ, only a few attaining the normal size, 26 × 13 μ.

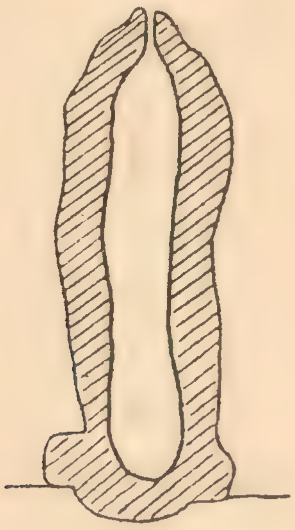

Fig. 2.—Long. section of Pycnidium, × 30.

It will be evident from the description and figures that these pycnidia are abnormal in shape. Their classification, however, does not depend on their shape. The pycnidia are almost superficial, or only slightly immersed ; hence they would be classified as *Diplodiella*.

Diplodiella was instituted by Karsten in Hedwigia, 1884, p. 62, as a subgenus, for species of *Diplodia* which have superficial pycnidia. It was raised to generic rank by Saccardo in Sylloge Fungorum, III., p. 375, and eleven species were there transferred to the new genus. Twenty-six more have since been enumerated in Saccardo. Many of the species of *Diplodiella* grow on wood, and it is perhaps to be expected that on a hard substratum the pycnidia of a *Diplodia* would tend to be superficial.

Other abnormal forms of *Botryodiplodia Theobromæ* were obtained in a pure culture of the fungus from *Hevea* on sugarcane agar. After four weeks' growth, the culture bore pulvinate masses, up to 5 mm. diameter, with pycnidia embedded in the upper part ; these were densely tomentose and resembled normal *Lasiodiplodia* stromata though they were not pseudoparenchymatous. But the greater number of the growths obtained were erect stromata, up to 1 cm. high and 5 mm. diameter (fig. 3). Some of these were conical,

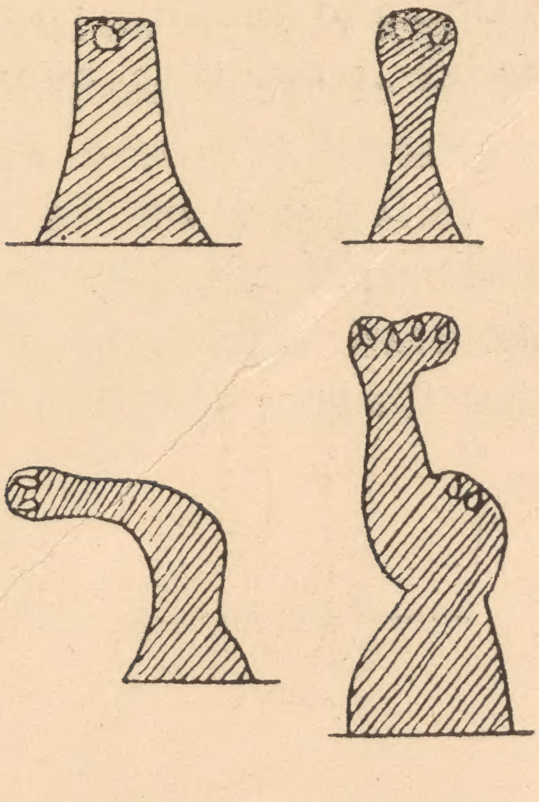

FIG. 3.—Stromata, × 3.

or conical to half their height, with the upper part cylindric; others were cylindric from the base, and many were constricted at intervals. Most of them were erect, but some bent over almost at right angles. The columns are composed of more or less parallel hyphæ and are not pseudoparenchymatous. The pycnidia are embedded in the apex of the stroma, as a rule, but if the stroma bears lateral protuberances, pycnidia are situated also on the upper surface of these. Up to ten pycnidia have been observed at the apex of a stroma; they have rather well-developed, acutely conical ostiola. All these stromata are densely tomentose.

The erect stromata appear to be abnormal forms of the *Lasiodiplodia* stroma, though they differ from the latter in texture. They are of interest, since, like the case first described, they indicate the potentiality of *Botryodiplodia Theobromæ* to produce superficial, erect structures. It is scarcely to be doubted that, should these forms be met with in nature, a new genus would be instituted for them.

The genus *Pellionella* was separated from *Diplodiella* for those species of the latter genus which have rostrate pycnidia. It contains two species only, *Pellionella Cardonia* Flag. and Sacc., which has scattered pycnidia, slightly immersed at the base, with a conical ostiolum sometimes equal in height to the diameter of the pycnidium, and *Pellionella deformans* Penz. and Sacc., which has pycnidia up to 0·7 mm. diameter, with an erect or oblique rostrum as long as the diameter of the pycnidium. None of the *Diplodiella* forms of *Botryodiplodia Theobromæ* referred to above were rostrate, though only a very slight variation would be required to fit them for inclusion in *Pellionella*. But, in view of the variations described, the published figures of *Pellionella deformans* strongly suggest that the type specimens of that species were abnormalities.

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